Swan Lake Habitat Rehabilitation and Enhancement Project

Pre-Project Biological and Physical Response Monitoring

Final Report

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1995

Abstract

The Swan Lake Habitat Rehabilitation and Enhancement Project (HREP) is designed to allow water level management within the confines of the 1150 ha lake to improve sediment conditions, manage water levels to produce annual emergent plants, and maintain habitat for fish. Most assumptions regarding habitat conditions and concerns regarding fish use of the lake were substantiated by pre-project monitoring. Flocculent sediments are apparently resuspended by wind generated waves and reduce light penetration in the lake. Emergent plants are confined to a narrow band around the shoreline and in the upper (managed) part of the lake. Submergent plants are found near the mouth of the lake and in the upper unit. Benthic invertebrates are most numerous in vegetated habitats, but have higher biomass in soft substrates. Fish use of the lake differs by season and location within the lake. We believe the project will improve sediments and plants, but reduce benthic biomass and fish use.

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Introduction

Swan Lake is a 1,150 ha (2,850 acre) backwater lake located on the Lower Illinois River near its confluence with the Mississippi River (Fig. 1). It was created in 1938 following completion of Lock and Dam 26 37 km (23 miles) downstream on the Mississippi River. Water level regulation necessary to maintain a nine-foot navigation channel inundated a large floodplain depression creating a contiguous backwater lake in what had been a mix of floodplain wetlands and forests. The lake is connected to the Illinois River at its extreme southern end and separated from the river along the rest of its length by a long, narrow peninsula. This peninsula, a natural levee, is frequently overtopped during high discharge events.

Immediately following its creation, Swan Lake supported abundant submersed aquatic plants, fish, and wildlife. Local guide services operating from Grafton, Illinois provided hunting and fishing opportunities for many visitors to the area. The lake has changed through time, however, in response to hydrologic manipulations and sedimentation from the Illinois River basin and local watershed. Aquatic plants have disappeared in the lake except near the connection with the Illinois River and in a managed unit (Upper Swan/Fuller Lakes) at the extreme northern end of the lake. Emergent aquatic plants are confined to a narrow band around the lake. They terminate at the water level maintained by Lock and Dam 26 in the lower portion of the lake, but are more abundant in the managed unit where levees and pumps reduce water levels below the stage maintained for navigation. Sediments in the lower portion of the lake are unconsolidated and easily resuspended by wind and boat generated waves. In the upper portion of the lake, sediments are firmer. Levees, islands, and plants eliminate most of the wind generated waves. The Swan Lake Habitat Rehabilitation and Enhancement Project (HREP; Fig. 2) is designed to sequester the lower portion of Swan Lake behind low levees to provide water level control for sediment and plant management similar to the capabilities currently available in the upper unit (USCOE 1993).

The project is expected to cause substantial ecological changes in the lake itself, but may also have effects beyond the lake. Migratory bird use of Swan Lake is expected to increase, but aquatic fauna will have reduced access to the lake. The major goal of monitoring activities was to enhance baseline information regarding fish communities, fish movement, and fish habitat use before and after project implementation. A multi-agency planning team (Illinois Dept. of Conservation (IDOC), US Fish and Wildlife Service (USFWS), US Army Corps of Engineers (COE), Southern Illinois University - Carbondale (SIU-C), Illinois Natural History Survey, the National Biological Service Environmental Management Technical Center (NBS EMTC)) cooperated to develop a broad monitoring program to evaluate waterfowl, fish, selected invertebrates, plants, sediments, and water quality.

This report is the product of a 12 month investigation (April, 1992 - February, 1993) conducted by the INHS Pool 26 Field station to document pre-project conditions for comparison to surveys scheduled after project completion. We investigated: spatial and temporal trends in water quality, sediment hardness and deposition, plant community distribution and submersed aquatic plant biomass, benthic and epiphytic invertebrate abundance and biomass, fish community composition and species relative abundance, and population age structure for several fish species. Results are presented separately for five types of investigations and summarized at the end. Our results agree with assumptions that guided the development of the project. They made a few new findings, and provide a baseline database to assess ecological response to the HREP.

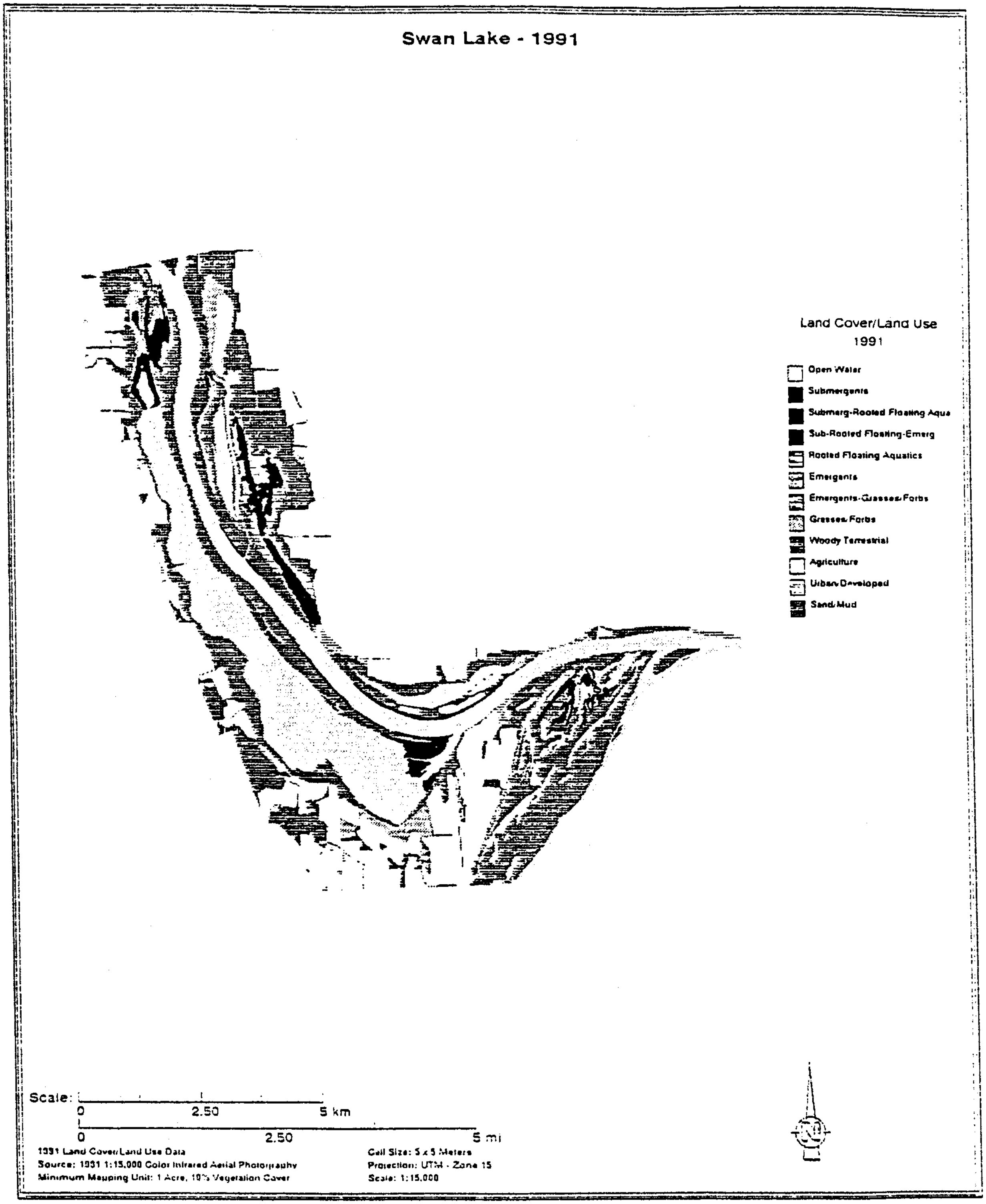


Figure 1. Swan Lake GIS coverage from 1991 (Source: EMTC land cover data base).

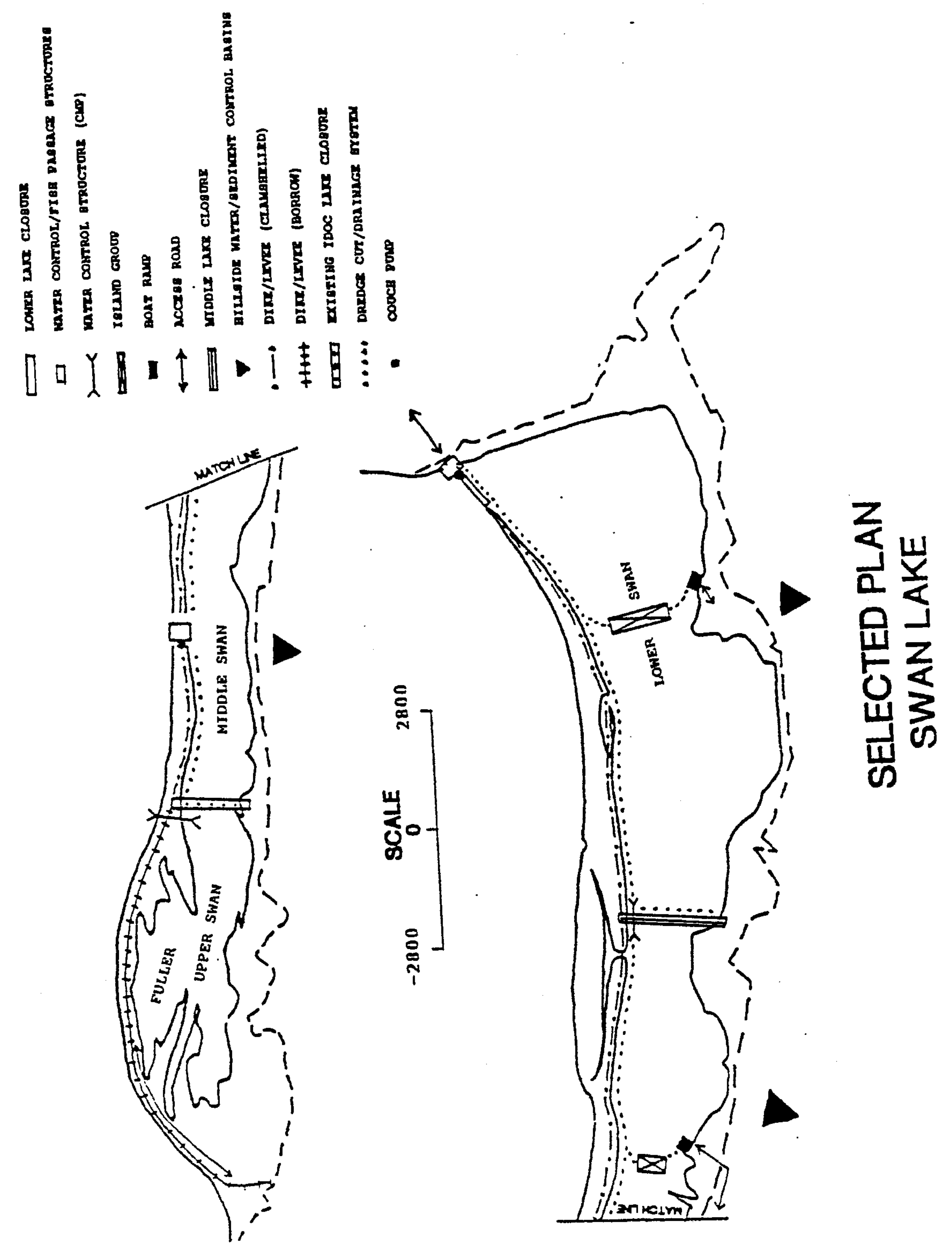


Figure 2. Swan Lake HREP project features.

Water Quality

Introduction:

The major water quality problem to be addressed by the Swan Lake HREP is high turbidity, presumably caused by wind generated waves resuspending flocculent sediments. High turbidity levels were presumed to limit growth of submersed aquatic plants. The HREP (Fig. 2) will provide water level management capabilities to dewater most of the lake to consolidate sediments through drying and compaction. Perimeter levees will also reduce the frequency of inundation by river water. Interior levees and island groups will reduce wind generated waves.

We took advantage of three Long Term Resource Monitoring Program (LTRMP) fixed site water quality stations that provided temporal data for 2 - 4 years between 1989 and 1993 depending on the parameter measured. We also established transects in each of the future compartments to assess spatial differences in water quality.

Methods:

Hydrologic data for the lower portion of the lake were obtained from the Environmental Management Technical Center (EMTC) water level database. They were plotted to show five year (Fig. 3) and study period (Fig. 4) hydrologic fluctuations. Water levels were obtained from the Grafton, Illinois gage located 8 km (5 miles) downstream from the mouth of the lake. Water levels in the upper portion of the lake (Fig. 5) were derived from discussion with the resource manager from the Illinois Department of Conservation (IDOC) and depth data from bi-weekly water quality sampling. Water level records are not available from the managed portion of the lake but were reconstructed to illustrate typical water level management plans used by the IDOC.

LTRMP water quality stations were located in the lower portion of the lake near the mouth (Fig. 6) and in the Illinois River at river mile (RM) seven, 3 km (2 miles) upstream from the mouth of the lake (not shown). All sites were monitored for basic LTRMP parameters beginning in 1989. In 1991, water quality parameters were expanded to include several new chemical parameters at one Swan Lake station and the river station. Transects were established in each future compartment to detect spatial characteristics of the basic LTRMP parameters. Sampling was conducted at five stations on each transect. Sample intervals were bi-weekly (every two weeks) on an annual basis at both transect and LTRMP stations.

Basic LTRMP parameters include: water depth (m), current velocity (cm/sec., measured with a Marsh-McBirney Model 201D digital velocity meter), wave height (cm), wind speed (km/hr, measured with a hand held anemometer), dissolved oxygen (mg/l, measured with a YSI model 57 DO meter), water temperature (degrees C, measured with the DO meter), secchi disk transparency (cm), turbidity (NTU, measured with a Hach turbidimeter), and conductivity (umhos/cm, measured with a LabComp SCT conductivity meter (LTRMP Procedures Manual, working draft).

Expanded LTRMP parameters were collected and shipped to U.S. Army Corps of Engineers, Waterways Experiment Stations (WES) analytical labs in Vicksburg, Mississippi and Eau Galle, Wisconsin. They were analyzed using standard methods appropriate for each of the 14 separate parameters. Parameters measured include: total suspended solids (mg/l), volatile suspended solids (mg/l), total soluble nitrogen (mg/l), ammonium-nitrogen (mg/l), nitrate/nitrite-nitrogen (mg/l), total nitrogen (mg/l), total soluble phosphorus (mg/l), soluble reactive phosphorus (mg/l), total phosphorus (mg/l), dissolved silica (mg/l), dissolved manganese (mg/l), dissolved iron (mg/l), phaeophyton (mg/m^3), and chlorophyll a (mg/m^3).

LTRMP data were averaged by week of the year to produce plots of temporal trends among the parameters measured (Figs. 7 - 14). Data from all LTRMP stations are overlaid to detect differences between river and lake water quality characteristics. Transect sampling data were averaged by transect to show temporal trends and plotted individually to illustrate spatial differences (Figs. 15 - 19). Tables 1 - 9 present monthly averages and ranges for basic parameters measured along transects.

Data analysis included Pearson correlation analysis (Table 10) of basic parameters measured along transects to detect causal relationships among water quality parameters. Analysis of variance procedures (Table 11) were used to test for differences and make comparisons among locations in Swan Lake. All analyses were tested with alpha = 0.05 using the Statistical Analysis System (SAS ????).

Results and Discussion:

Water Levels

Water levels during the 5 year period of LTRMP sampling (Fig. 3) were stable due to dam control during drought periods in 1988 and 1989. Spring flooding in 1990 and 1991 breached the natural levee and inundated Swan Lake with river water. Water levels rose in the spring and fall of 1992 as is typical in this river reach, and were followed by extreme spring and summer flooding in 1993.

Pool 26 and Alton Pool are managed using mid-pool control methods that strive to regulate water levels between 127.4 and 128.0 m above mean sea level. Dam gates are opened to hold water levels below the maximum regulated pool stage (128.0 m MSL) as discharge increases. Dam operations can reduce water levels from "normal" regulated levels during certain flow conditions (Fig. 4). Shoreline areas (25 - 50 m wide) in the lower portion of Swan Lake are influenced by minor adjustments in water levels because of their gradual slope.

Upper Swan/Fuller lakes are surrounded by a low levee to protect the area from river fluctuations and also to provide complete drawdown capabilities. Water level management goals are determined based on plant response to hydrologic conditions in the area during the spring and early summer. If the area is not inundated by river water, it may develop submersed aquatic plants in open water beyond the fringe of emergent plants. In 1992, local managers held water through July because submersed aquatic plants were unusually abundant. Pumping in August dewatered the site to promote growth of emergent aquatic plants beneficial for wildlife (Fig. 5). In other years, drawdowns occured as early as July.

Temporal Trends and River/Backwater Comparisons

LTRMP sampling data is presented for each station as the average value recorded for each parameter for weekly intervals during four years (1989 - 1992) that monitoring data was collected. Differences between river and backwater stations can be detected in some cases.

Wave height (Fig. 7) was the higher at the backwater lake stations than the river during spring and fall. During the summer, waves were small and all sites exhibited similar conditions. The two Swan Lake sites are located at the extreme southern end of the lake and are frequently exposed to whitecaps that develop along the long axis of the lake on windy days.

Water depth (Fig. 7) at the three stations roughly paralleled each other, but illustrate the difference in station depth at the backwater and river locations. The river station was about 1 m deep at controlled river stage. Backwater stations were about 0.5 m deep at controlled river stage.

Temperatures (Fig. 8) followed an annual pattern with temperatures approaching, but not reaching, 0^{0} C at all stations during winter periods.

Dissolved oxygen (Fig. 8) in the river decreased through the summer in a pattern inverse to the temperature curve. The backwater stations were more variable, but generally tracked each other. Submersed aquatic plants in the backwater lake can produce supersaturated conditions when present, but may also respire and consume oxygen at night and after senescence. Lack of flow in the backwater lake contributes to periods of low oxygen.

Secchi disk transparency (Fig. 9) extremes occurred at backwater stations. The two backwater stations are similar in pattern, but SL1 (I005.8K) appears more variable, perhaps due to its location in relation to the submersed aquatic plant bed at the mouth of the lake that may trap particles in the water. The river station was relatively stable between 20 and 30 cm secchi disk depth compared to the backwater stations that ranged from 5 - 45 cm.

Turbidity (Fig. 9) was generally inversely related to secchi disk transparency. Backwater stations were more variable than the river. They also recorded the highest and lowest average values.

Chlorophyll a (Fig. 9) was highest at the backwater station. There appears to be peaks in chlorophyll a in the fall at both stations. Winter peaks (week 52 and week 6) appear confined to the backwater stations. Lowest chlorophyll a concentrations occur in late summer and late fall.

Total suspended and volatile suspended solids (Fig. 10) are very similar in pattern at both stations, volatile solids (organic matter) compose about 10% of the suspended matter at both stations. The two sites show similar quantities of suspended solids through the year, except in late summer when the backwater station has significantly more suspended matter and in December where there was a suspended matter peak in the river. The divergence during summer may relate to the higher quantity of algae and wave disturbed sediments in the backwater. Differences in December may be the result of leaf transport in the river channel but not the backwater.

Soluble total nitrogen (Fig. 10) differs in the spring when river water may be carrying higher nutrient loads from spring run-off. Inundation of the backwater may explain the occasions when springtime nutrient concentrations at both stations converge. Through the rest of the year patterns in soluble total nitrogen follow similar seasonal patterns with concentrations slightly higher in the river compared to the backwater. An interesting parallel is the drop in soluble total nitrogen between weeks 32 and 40 correspond with increases in chlorophyll a concentrations.

Total nitrogen (Fig. 11) follows a seasonal pattern comparable to soluble total nitrogen, but total nitrogen concentrations are, expectedly, higher. A general seasonal pattern exhibits reduced nitrogen concentrations during the growing season than in fall and winter. The pattern may be related to both nitrogen transport during higher flow periods and utilization of resources by algae and aquatic plants.

Nitrate/nitrite-nitrogen (Fig. 11) followed a pattern and exhibited concentrations very similar to soluble total nitrogen. The river had consistently higher concentrations than the backwater. The dip in nitrate/nitrite-nitrogen concentrations between weeks 32 and 40 is suspected to be the result of algal activity.

Ammonium-nitrogen (Fig. 11) was frequently below detection levels at the backwater location. When detectable, patterns in ammonium concentrations paralleled the other nitrogen compounds.

Phosphorus compounds (Fig. 12; total phosphorus, soluble reactive phosphorus, and total soluble phosphorus) were usually similar at backwater and channel locations except during the fall algal bloom. During the fall, phosphorus compounds more than tripled in concentration which may have fueled the algal bloom. The increase may be the result of nutrient release from senescing submersed aquatic plants near the mouth of the lake.

Dissolved calcium, chloride, and potassium (Fig. 13) followed similar seasonal trends in both backwater and river habitats. No strong seasonal effects were detected in the three parameters, except for late in the growing season when dissolved potassium and chloride increased slightly, and calcium concentrations dropped slightly.

pH (Fig. 14) was variable between 8 and 9. The river station generally had lower and more stable pH than the backwater stations. Backwater pH was likely influenced by plant and algae production in the backwater lake.

Phaeophyton (Fig. 14) is an algal product and paralleled algal concentrations at both locations.

Dissolved silica (Fig. 14) was variable, but generally higher when chlorophyll concentrations were low.

Dissolved iron and manganese (Fig. 15) concentrations were frequently below detection levels, but generally more abundant during the growing season.

Conductivity (Fig. 15) was highest during spring, dropped during summer, and increased again during the fall. The cycle corresponds with flow that may deliver higher quantities of salts from the basin during spring and fall floods.

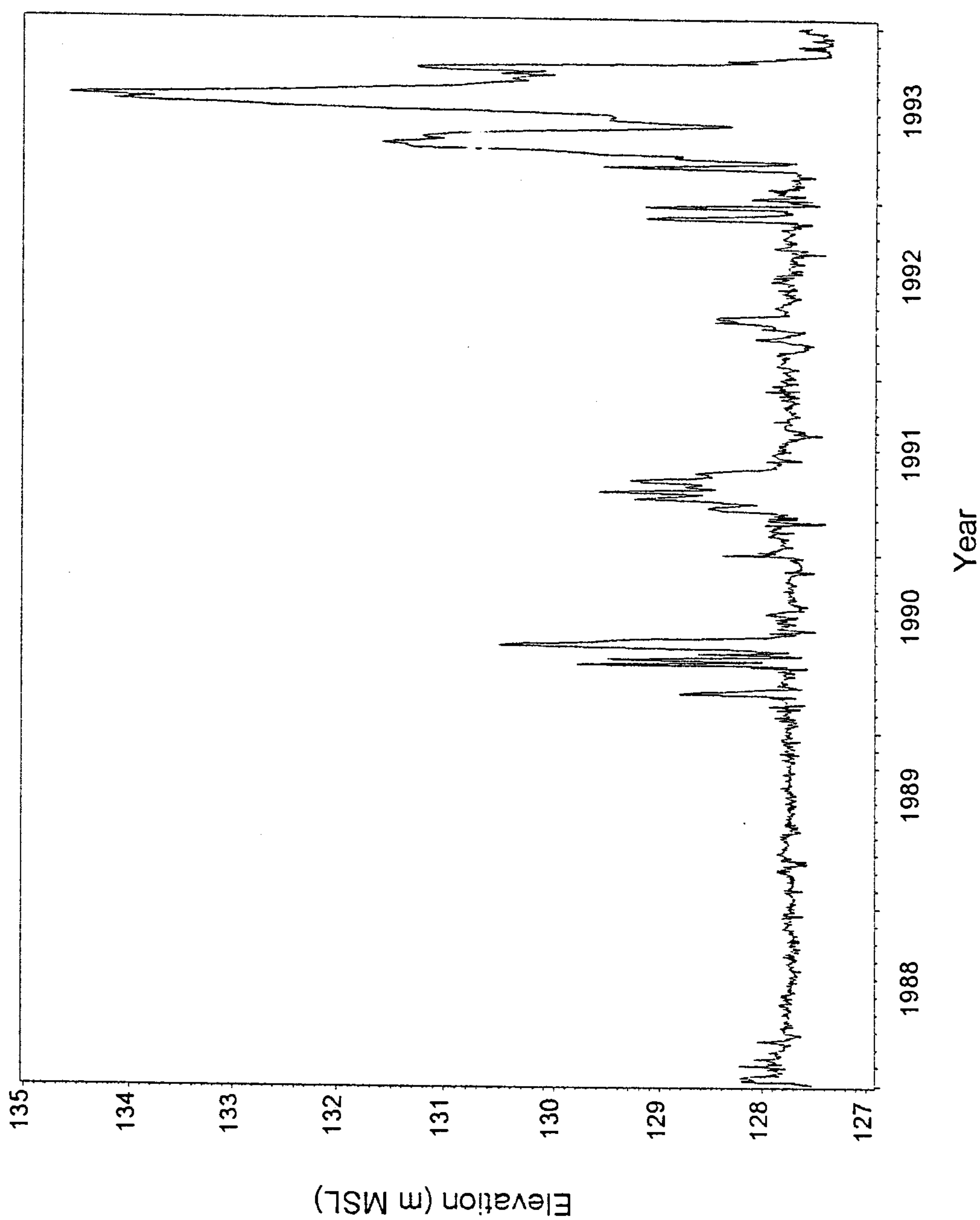


Figure 3. Five year water surface elevations (m above mean sea level, NGVD 1929) at Grafton, Illinois, located 8 km (5 miles) downstream from Swan Lake.

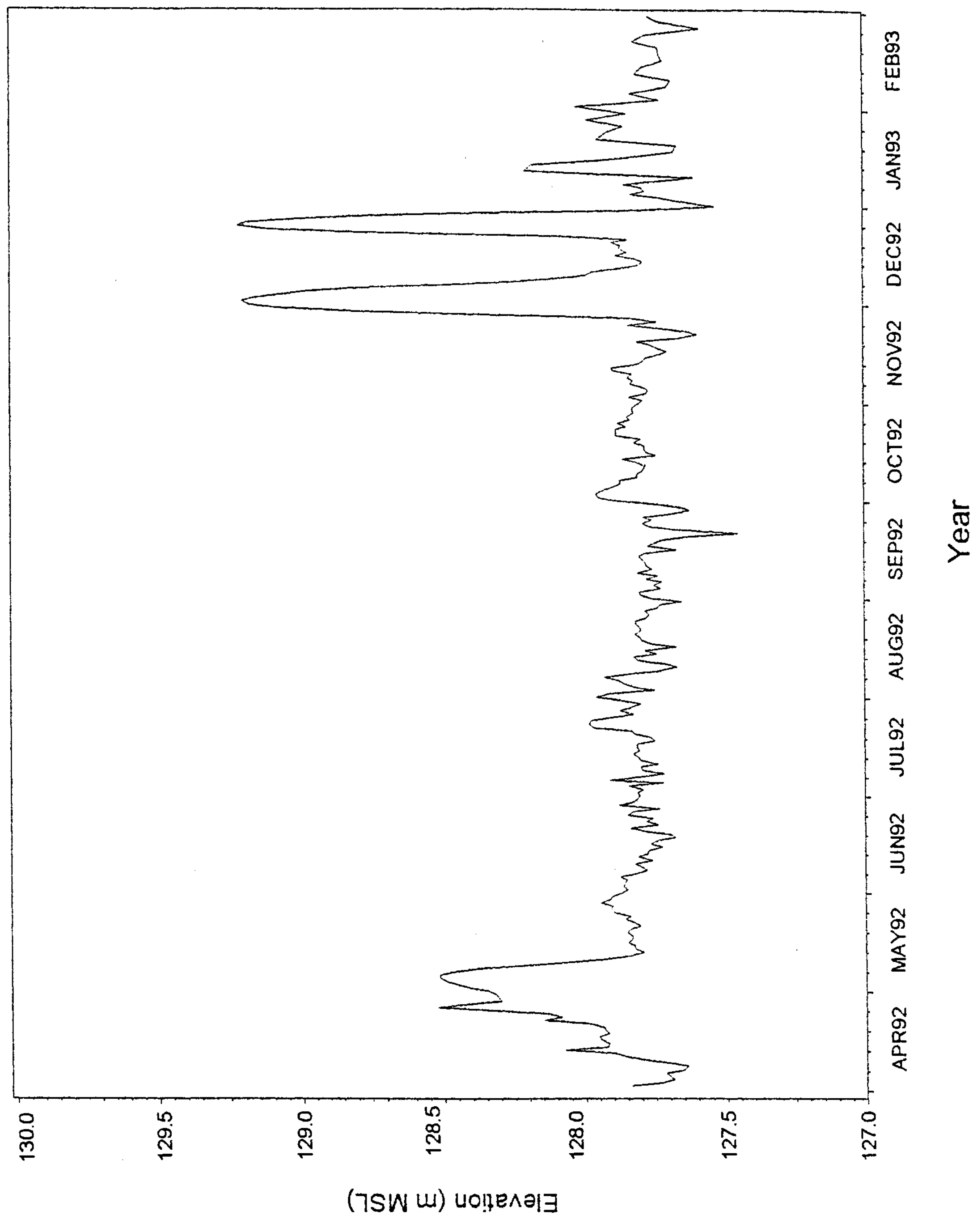


Figure 4. Study period water surface elevations (m above mean sea level, NGVD 1929) at Grafton, Illinois, located 8 km (5 miles) downstream from Swan Lake. The horizontal lines represent the approximate dam control range at Swan Lake.

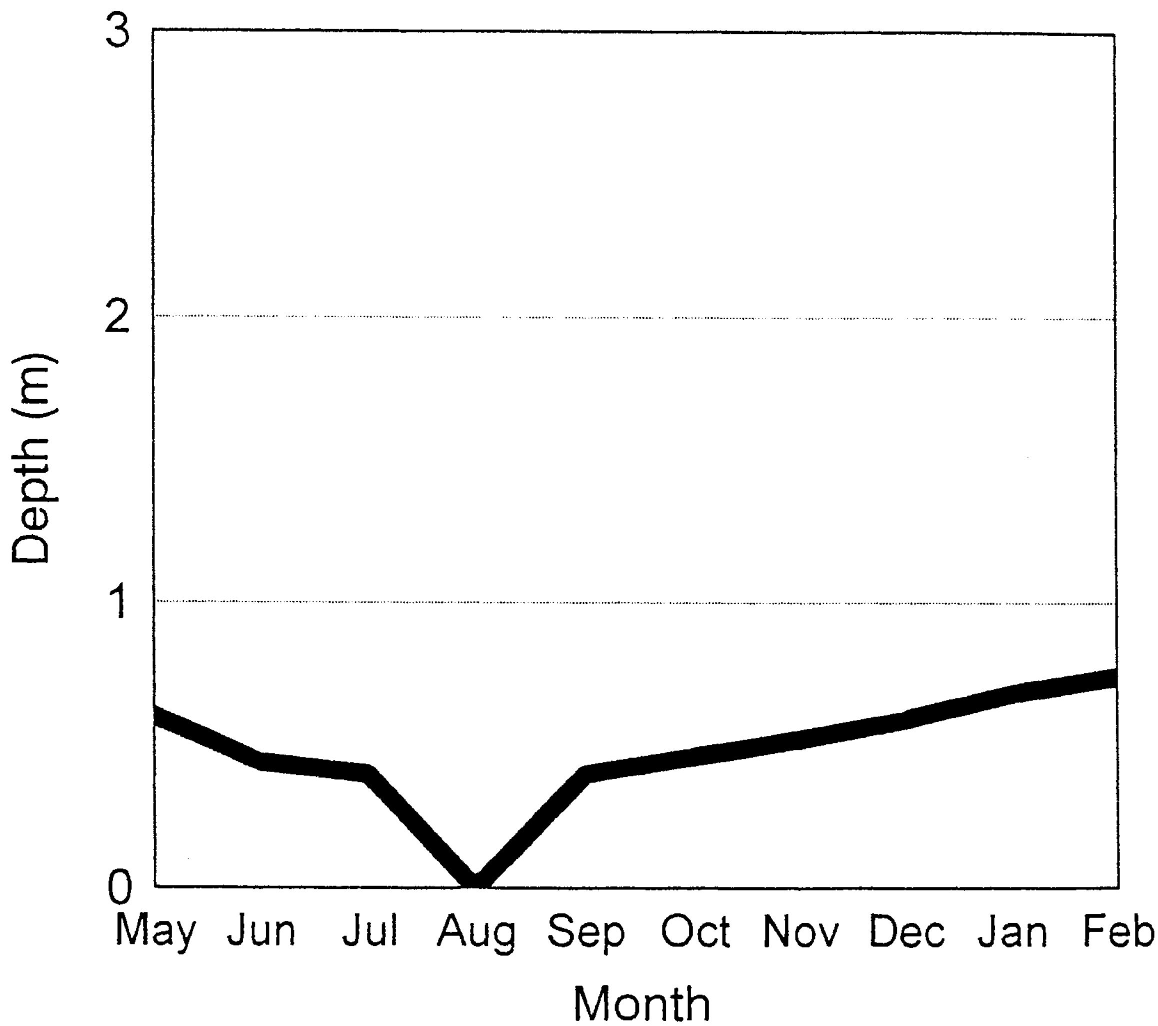


Figure 5. Reconstructed water levels in the upper unit of Swan Lake.

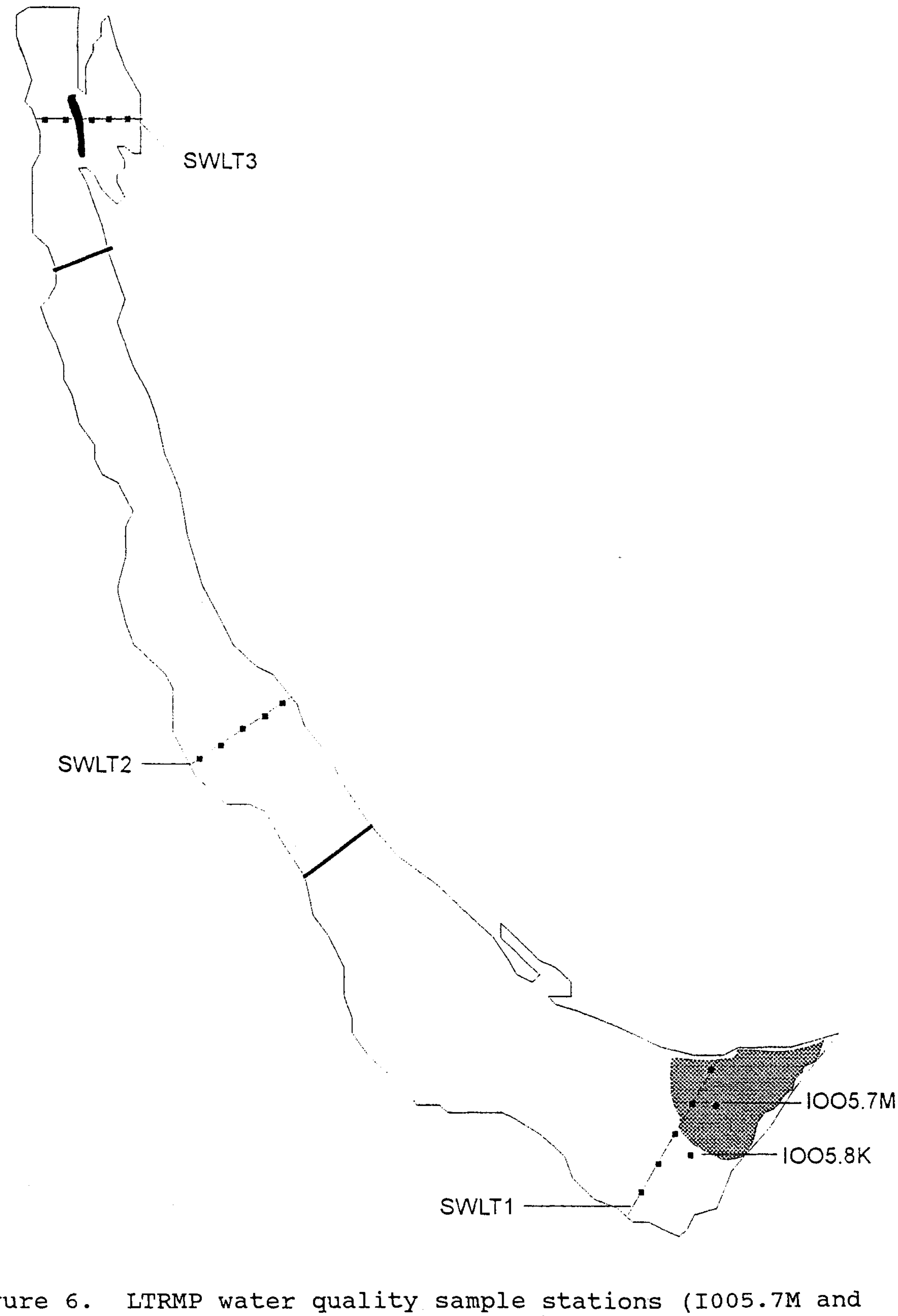


Figure 6. LTRMP water quality sample stations (I005.7M and I005.8K) and transect locations in Swan Lake (I007.0W in the Illinois River is not shown, but is located about 3 km upstream on the west side of the river).

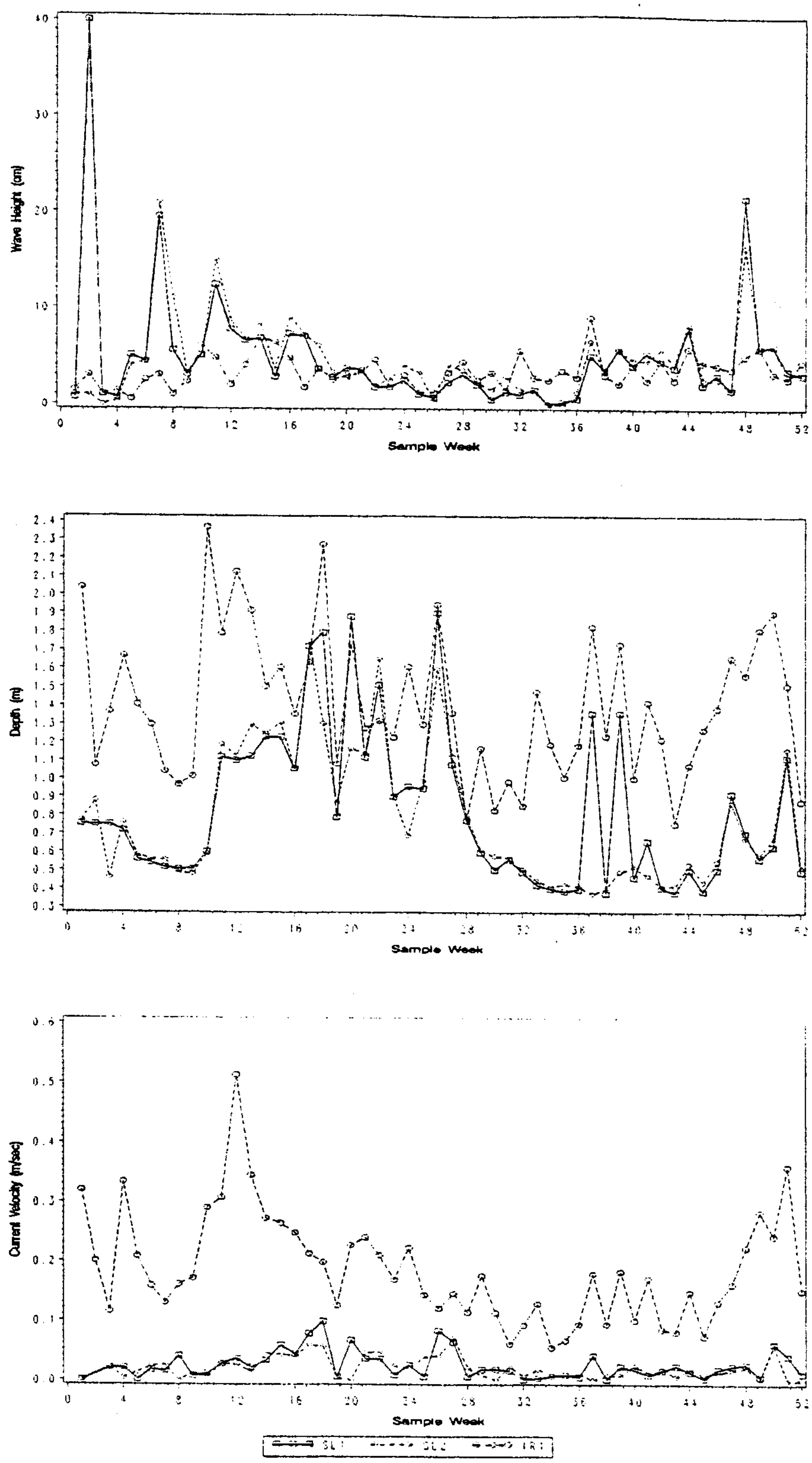


Figure 7. Four year average weekly wave height (cm), water depth, and current velocity at LTRMP sample stations in Swan Lake and the Illinois River.

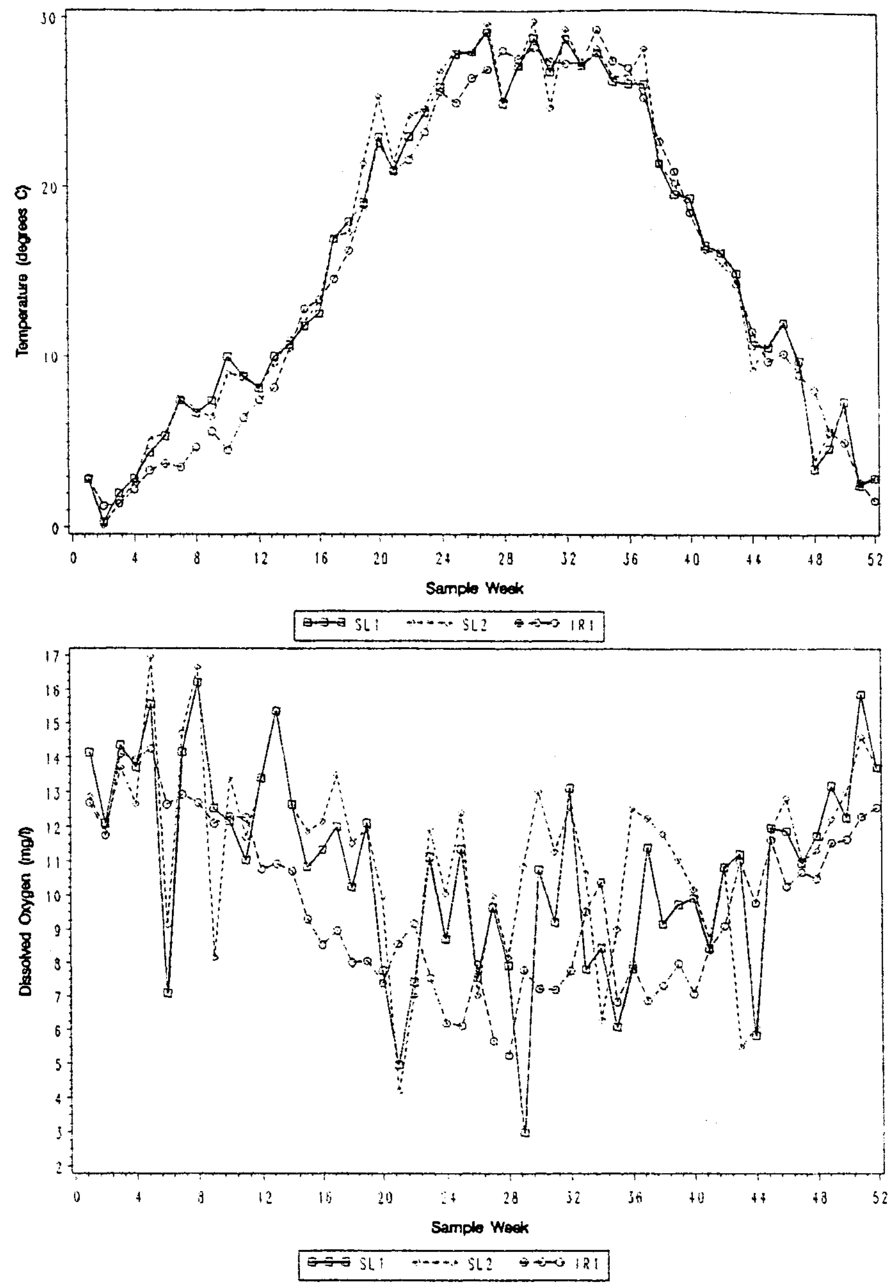


Figure 8. Four year average weekly temperature (^{0}C) and dissolved oxygen (mg/l) at LTRMP sample stations in Swan Lake and the Illinois River.

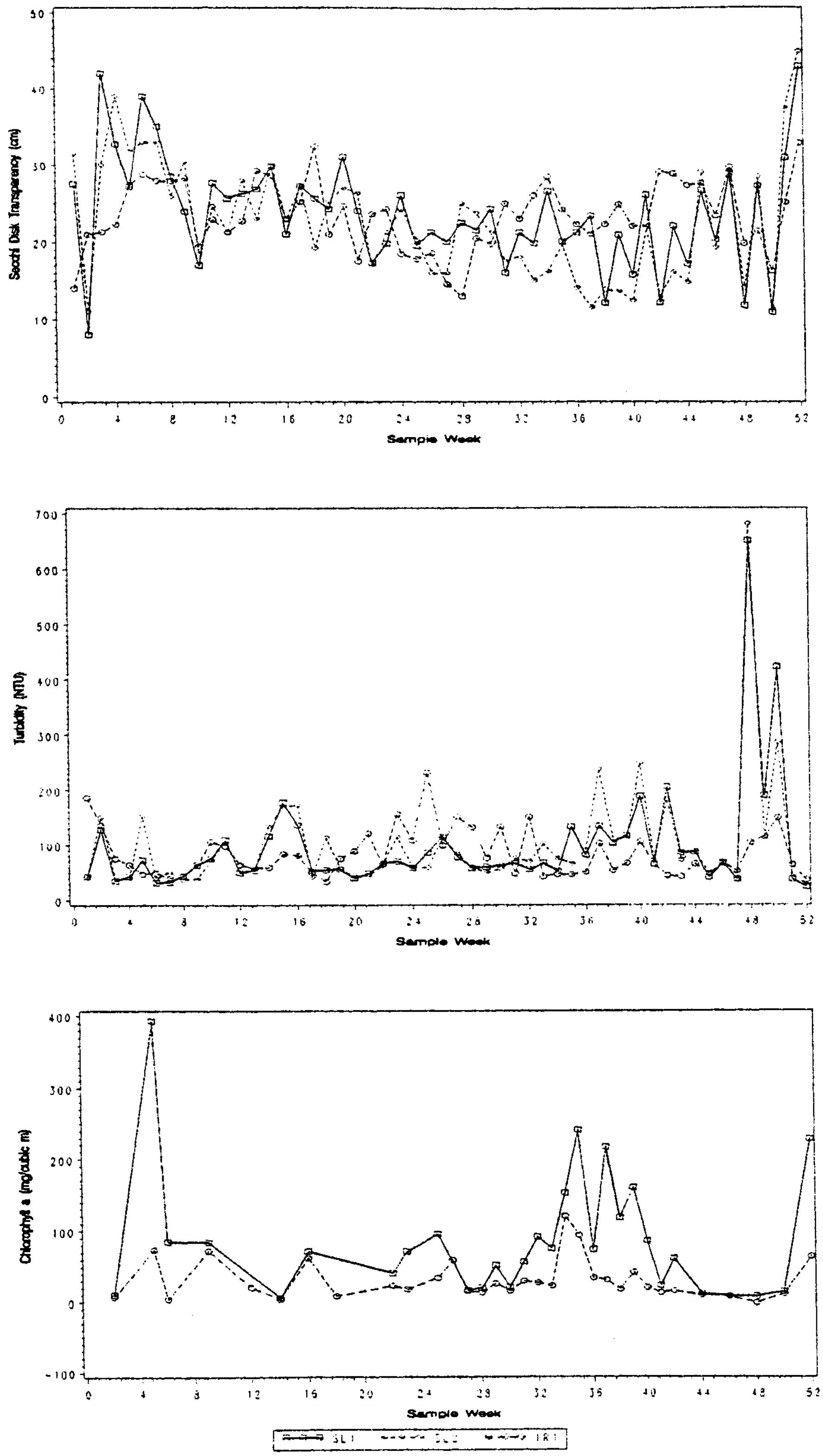


Figure 9. Four year average weekly secchi disk transparency (cm), turbidity (NTU), and Chlorophyll a (mg/m^3) at LTRMP sample stations in Swan Lake and the Illinois River.

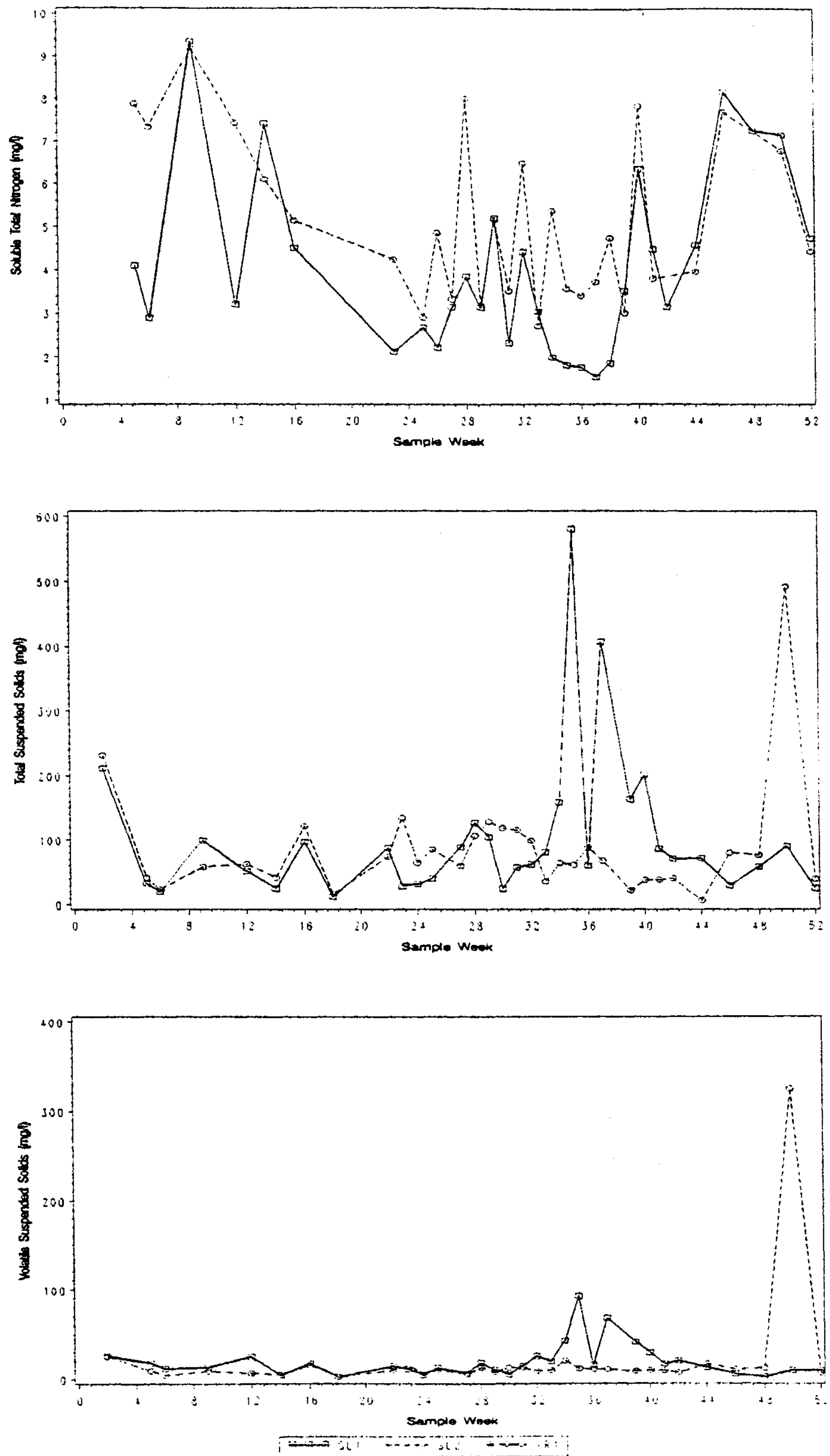


Figure 10. Four year average weekly soluble total nitrogen (mg/l), total suspended solids (mg/l), and volatile suspended solids (mg/l) at LTRMP sample stations in Swan Lake and the Illinois River.

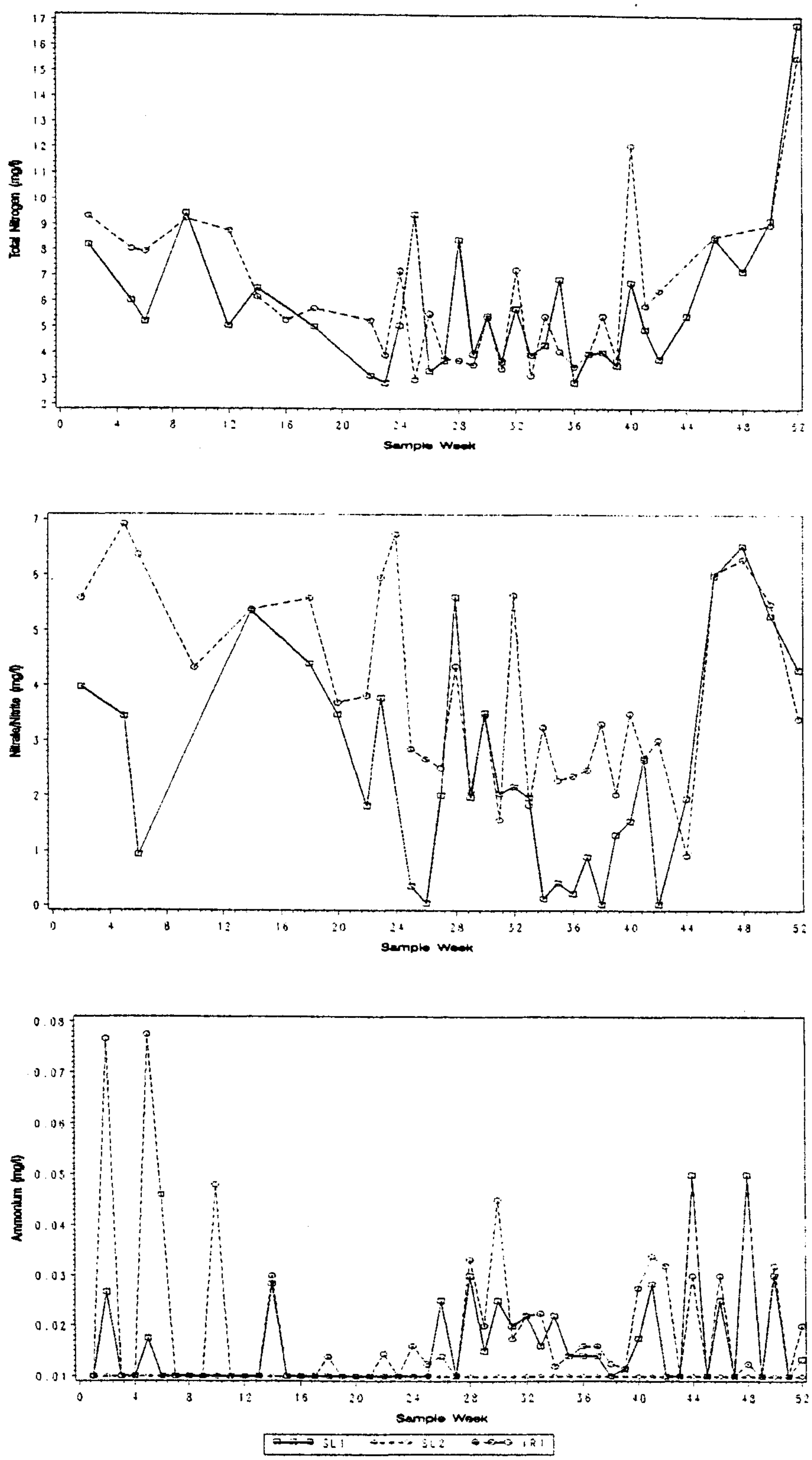


Figure 11. Four year average weekly total nitrogen (mg/l), nitrate/nitrite-nitrogen (mg/l), and ammonium-nitrogen (mg/l) at LTRMP sample stations in Swan Lake and the Illinois River.

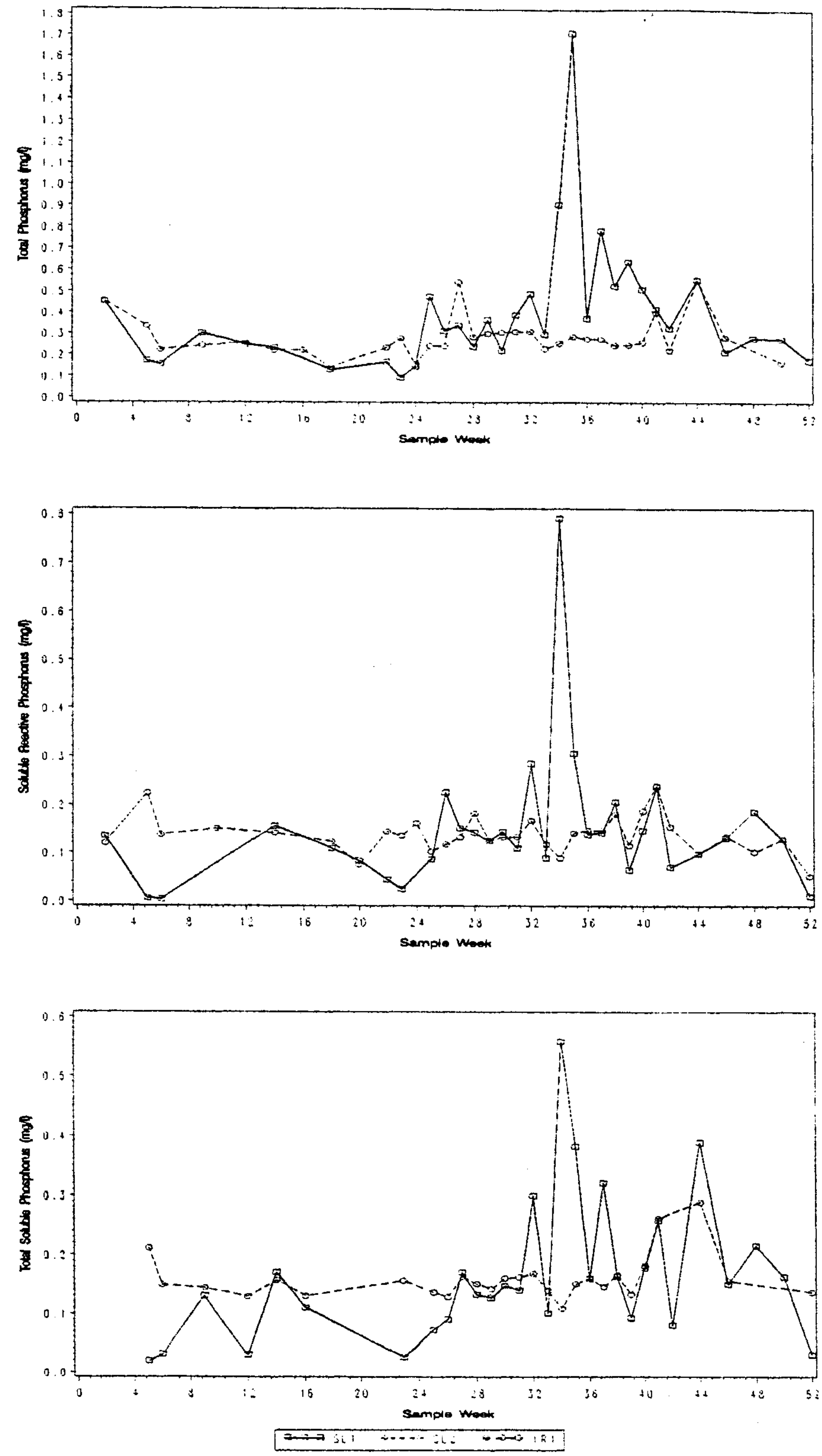


Figure 12. Four year average weekly total phosphorus (mg/l), soluble reactive phosphorus (mg/l), and total soluble phosphorus (mg/l) at LTRMP sample stations in Swan Lake and the Illinois River.

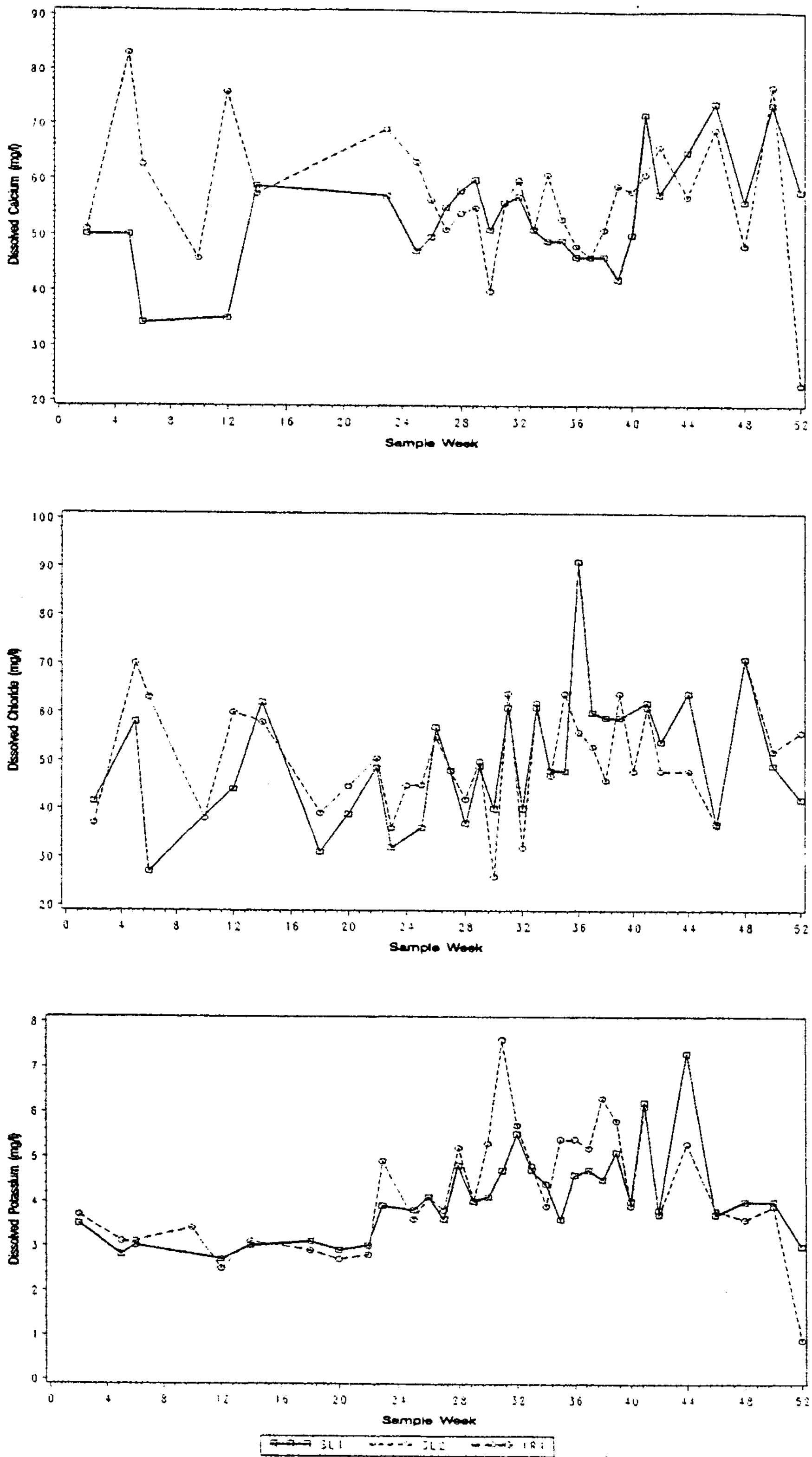


Figure 13. Four year average dissolved calcium (mg/l), dissolved chloride (mg/l), and dissolved potassium (mg/l) at LTRMP sample stations in Swan Lake and the Lower Illinois River.

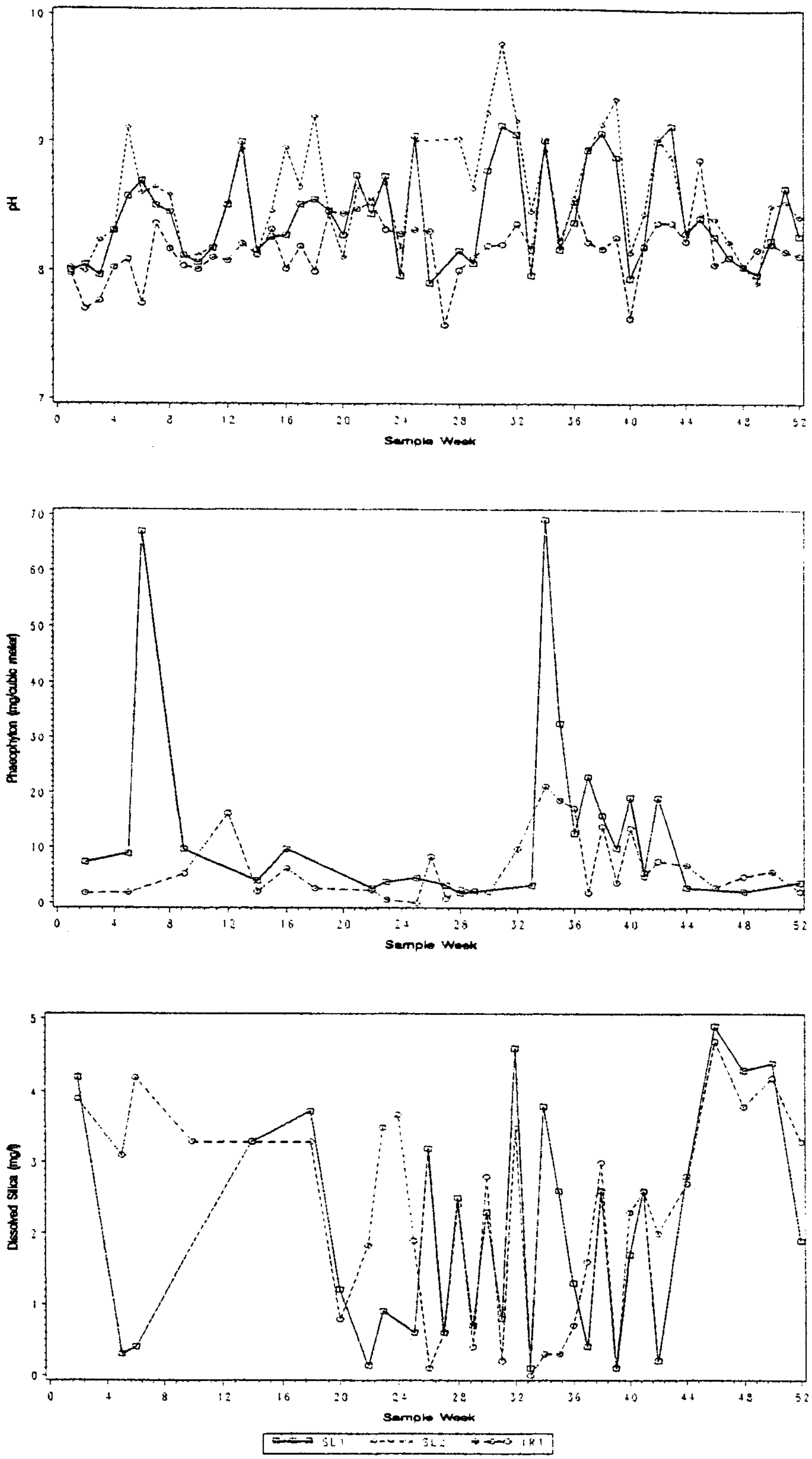


Figure 14. Four year average weekly pH, phaeophyton (mg/m^3), and dissolved silica (mg/l) at LTRMP sample stations in Swan Lake and the Illinois River.

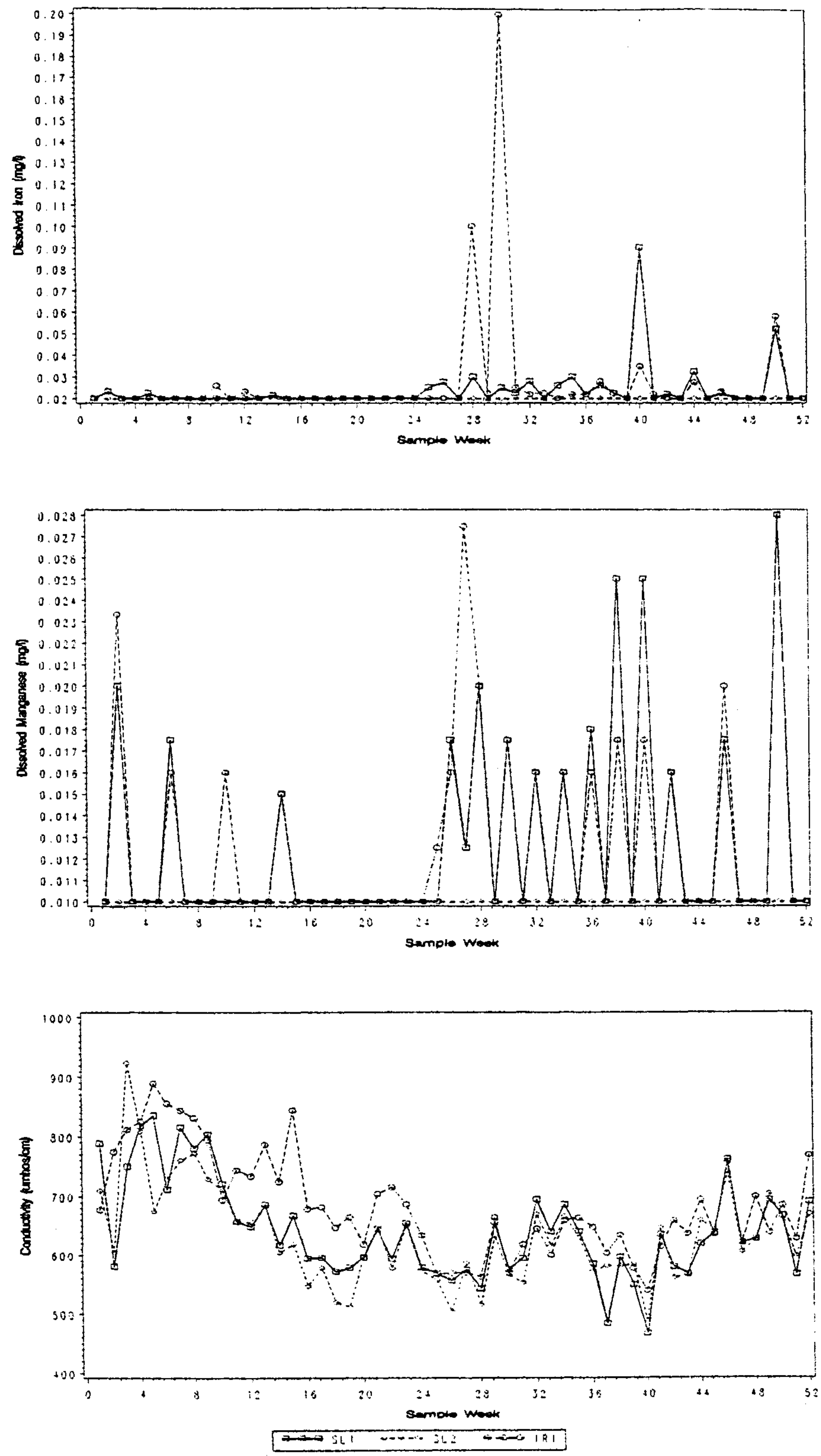


Figure 15. Four year average weekly dissolved iron (mg/l), dissolved manganese (mg/l), and conductivity (umhos/cm) at LTRMP sample stations in Swan Lake and the Illinois River.

Spatial Comparisons

Water quality data collected along transects in each future lake compartment were plotted to examine spatial differences in the basic LTRMP water quality parameters. Tables present the average value and range of measurements along each transect. Pearson correlation analyses (Table 1) were used to detect relationships among variables. Analysis of variance was used to compare among units (Table 2).

Water depth (Fig. 16; Table 3) in the lower and middle unit parallel each other in response to changes in river stage. The lake is deepest in the middle with regulated stage maximum depths of about 1 m down the middle of the lake. The lake bottom slopes gradually to the regulated stage shorelines and terminates at a fringe of herbaceous then woody vegetation. The upper unit is managed behind a protective levee and thus exhibits a different pattern in water depths. Water levels in the unit are typically held at a stable elevation that provide maximum depths of approximately 1.0 m. The upper unit is deepest at the cross levee and slopes gradually up to the wooded shoreline. Drawdowns occurred in August, 1992. The site was reflooded in September, 1992 after aerial seeding with Japanese millet (a fast growing forage plant). Water depths were similar in the lower and middle unit, they were also greater than in the upper unit (Table 2).

Current velocity was negligible at all Swan Lake locations (Fig.

16; Table 4). Current velocity was detectable in the lower and middle unit but not in the upper unit. Currents were suspected to be produced by wind and waves, but our sampling did not detect a strong relationship (Table 1). Current velocity was greater in the two lower units than in the upper unit (Table 2). We suspect water exchange between the river and lake occurs as a result of convection currents and eddies. The subject should be more thoroughly examined to determine the ecological importance of the water exchange.

Wind speed (Fig. 17; Table 5) was correlated with wave height. Wind speeds were typically similar in the lower and middle unit and higher than in the more sheltered upper unit. Sampling in June, 1992 may represent a day when winds were coming up the lake from the South instead of down the lake which is more typical. Wind speed was greater in the lower and middle units than in the smaller, more sheltered upper unit (Table 2).

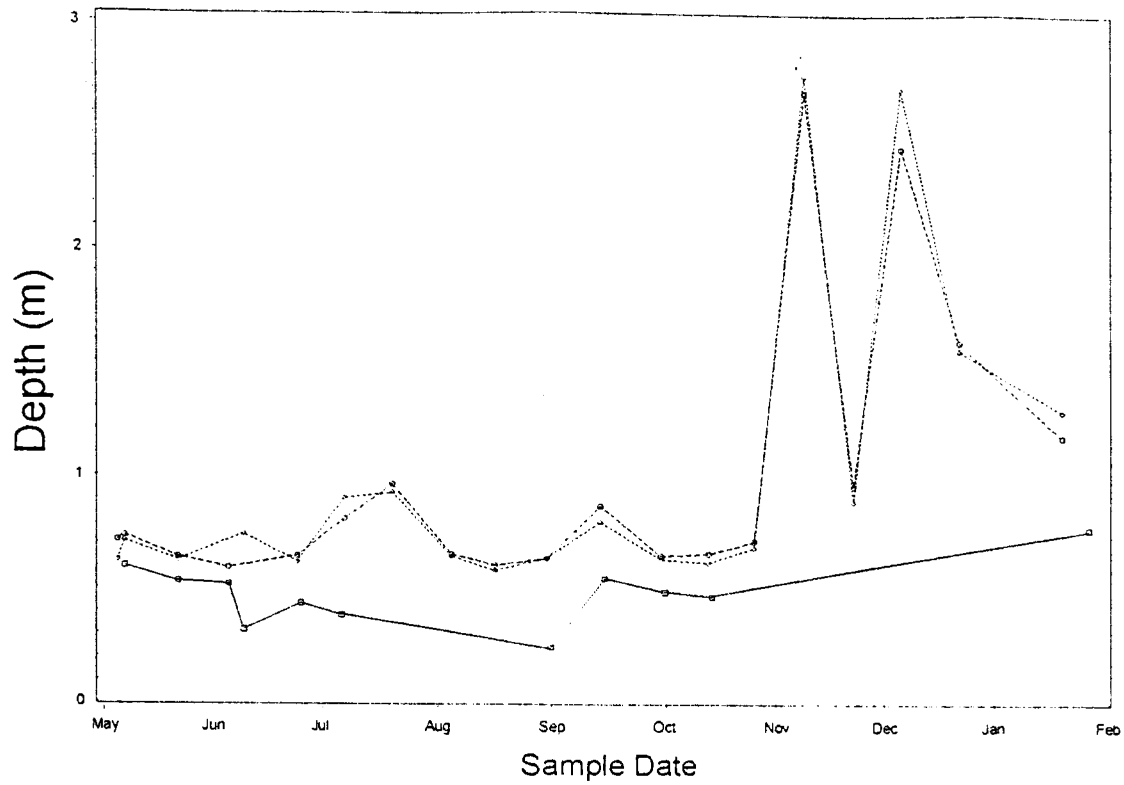
Average wave heights (Fig. 17; Table 6) appear low because of a gradient in wave size with the largest waves in the windward side and center of the lake. On windy days, 0.5 m waves can make anchoring a boat difficult in the loose sediments. There is a strong correlation between wind speed and wave height (Table 1), and to a lesser degree between turbidity and secchi disk transparency. Wave heights were similar in the two lower units and higher than in the upper unit (Table 2).

Water temperatures (Fig. 18; Table 7)) were uniform throughout the lake. Fall and winter samples were missed in the upper unit during hunting season, so no measurements were available for comparison to the other units. The lower and middle unit did not reach 0^0 C. Temperature was inversely related to dissolved oxygen concentration (Table 1). Temperature did not differ among lake units.

Dissolved oxygen (Fig. 18; Table 8) gradually increased through the monitoring period at the lower and middle transects. The upper unit had abundant submersed aquatic plants that caused oxygen super saturation on sample dates in June, 1992. Dissolved oxygen levels were generally high and do not appear threatening to aquatic life during any time of year. Dissolved oxygen was higher in the upper unit, in response to aquatic plants, than in the lower units where plants were absent along transects (Table 2).

Secchi disk transparency and turbidity (Fig. 19; Tables 9 and 10) both provide measures of water clarity. Both variables were loosely correlated with wind speed and wave height. Water clarity was always higher in the upper unit than in the other units (Table 2). Mechanisms assumed to contribute to the high water clarity in the upper unit are: 1. regular summer drawdowns, 2. less wind exposure, and 3. submersed and emergent aquatic plants.

Conductivity (Fig. 20; Table 11) was lowest in the upper unit compared to the two lower units that were connected to the Illinois River (Table 2). There were no strong correlations among other parameters measured (Table 1).



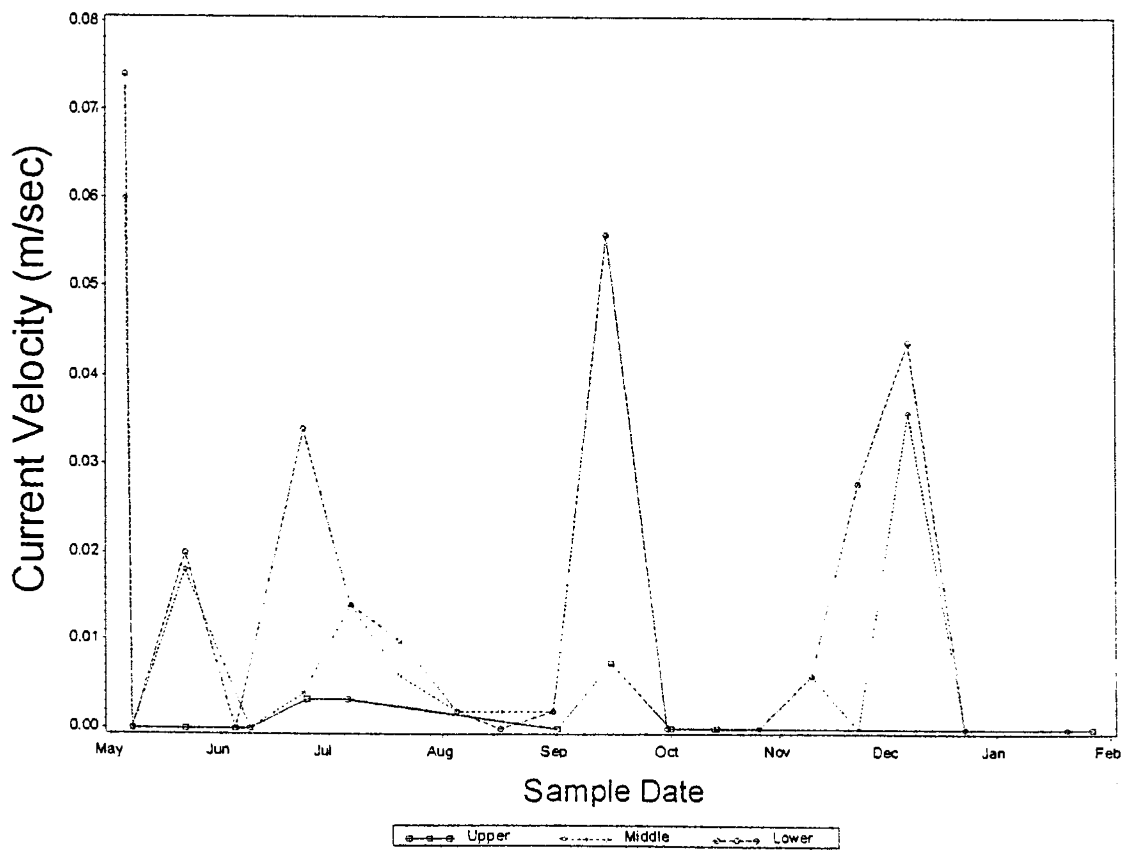


Figure 16. Average bi-weekly depth (m) and current velocity (m/sec.) at transect stations in Swan Lake, from May, 1992 to February, 1993).

Table 1. Pearson correlation coefficients among water quality parameters measured along transects in Swan Lake. All values are significant at alpha=0.05, ( )=number of samples.

	Wave Height	Wind Speed	Depth	Temp.	DO	Turb.	Current Velocity	Cond.	Secchi
Wave Height	1.0								
Wind Speed	0.70 (234)	1.0							
Depth	NS	NS	1.0						
Temp.	NS	NS	-0.59 (234)	1.0					
DO	NS	NS	0.21 (234)	-0.51 (231)	1.0				
Turb.	0.43 (231)	0.33 (234)	-0.16 (231)	0.39 (234)	-0.29 (231)	1.0			
Current Velocity	0.29 (230)	0.20 (232)	0.16 (232)	NS	NS	0.12 (232)	1.0		
Cond.	NS	NS	NS	0.21 (228)	-0.34 (228)	0.35 (228)	-0.14 (232)	1.0	
Secchi	-0.39 (231)	-0.27 (234)	NS	-0.37 (234)	0.30 (231)	-0.68 (234)	-0.24 (232)	-0.41 (228)	1.0

Table 2. Spatial comparison of water quality parameters in Swan Lake. ANOVA and means comparisons were tested at alpha=0.05. Upper Swan=L, Middle Swan=M, and Lower Swan=L.

Parameter	N	F value	P	Means Comparison
Wind Speed	234	5.20	0.006	(L=M)>U
Wave Height	231	21.6	<0.0005	(L=M)>U
Current Velocity	231	7.73	<0.0005	(L=M)>U
Turbidity	234	45.43	<0.005	M>L>U
Secchi Disk Transparency	234	57.75	<0.005	U>(L=M)
Dissolved Oxygen	231	4.67	0.01	U>L>M
Depth	235	12.89	<0.0005	(L=M)>U
Conductivity	227	30.00	<0.0005	(L=M)>U

Table 3. Depth (m) at transect stations in Swan Lake May 1992 to February 1993.

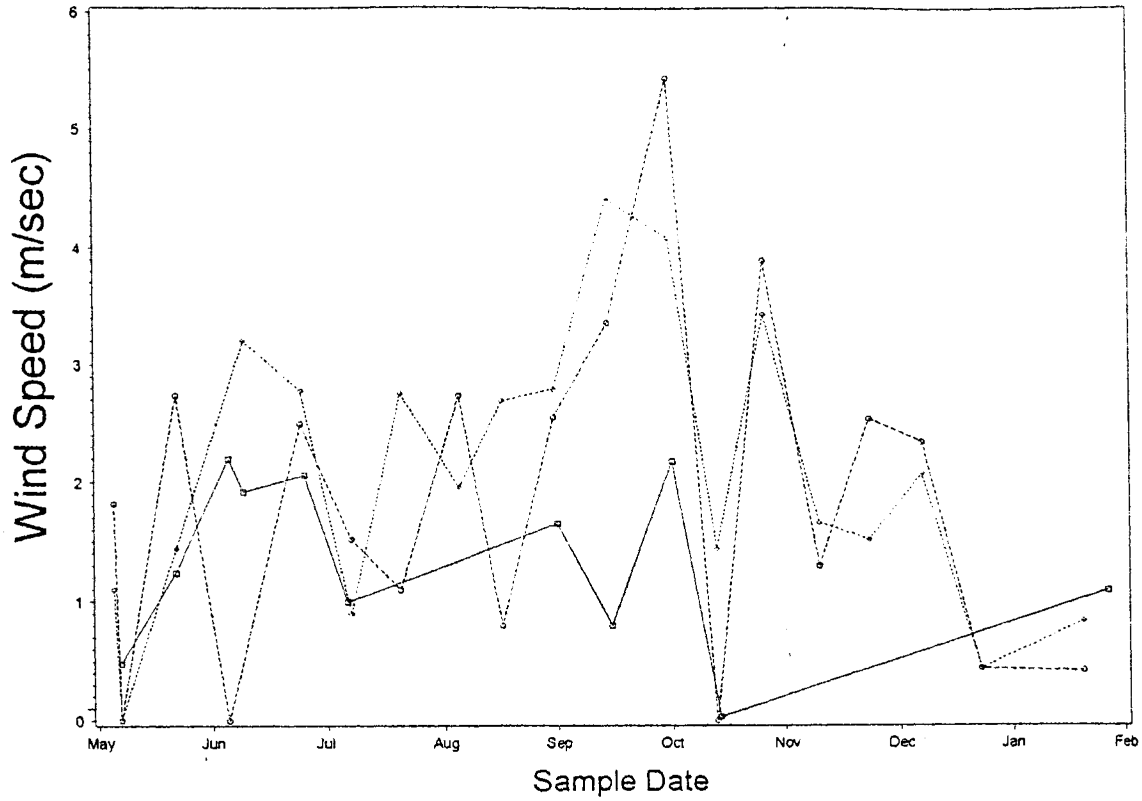
	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	.72	1.41-1.68	.67	.45-.85	.60	.42-.78
June	.61	.49-.72	.67	.45-.91	.44	.19-.71
July	.72	.49-1.00	.75	.39-1.10	.40	.33-.49
August	.73	.45-1.03	.70	.33-1.05	*	*
September	.74	.52-.93	.70	.40-.94	.40	.18-.63
October	.63	.48-.83	.60	.39-.76	.46	.18-.60
November	1.68	.57-2.80	1.71	.54-2.90	*	*
December	1.67	.79-2.70	1.77	.69-2.83	*	*
January	1.56	1.41-1.68	1.52	1.32-1.67	*	*
February	1.14	.99-1.20	1.25	.96-1.40	.74	.62-.90
Totals	.97	.45-2.80	.99	.33-2.90	.51	.18-.90

*=sample not taken

Table 4. Velocity (m/sec) at transect stations in Swan Lake May 1992 February, 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	0.04	.0-.10	0.03	.0-.09	0.0	*
June	0.01	.0-.03	0.01	.0-.03	0.0	*
July	0.02	.0-.07	0.01	.0-.03	0.0	.0-.01
August	0.0	.0-.01	0.0	.0-.01	*	*
September	0.03	.0-.08	0.03	.0-.07	0.01	.0-.02
October	0.0	*	0.0	*	*	*
November	0.0	.0-.02	0.0	.0-.02	0.0	*
December	0.04	.02-.06	0.02	.0-.04	*	*
January	0.0	*	0.0	*	*	*
February	0.0	*	0.0	*	*	*
Totals	0.02	.02-.05	0.01	.0-.04	0.0	.0-.0

*=sample not taken



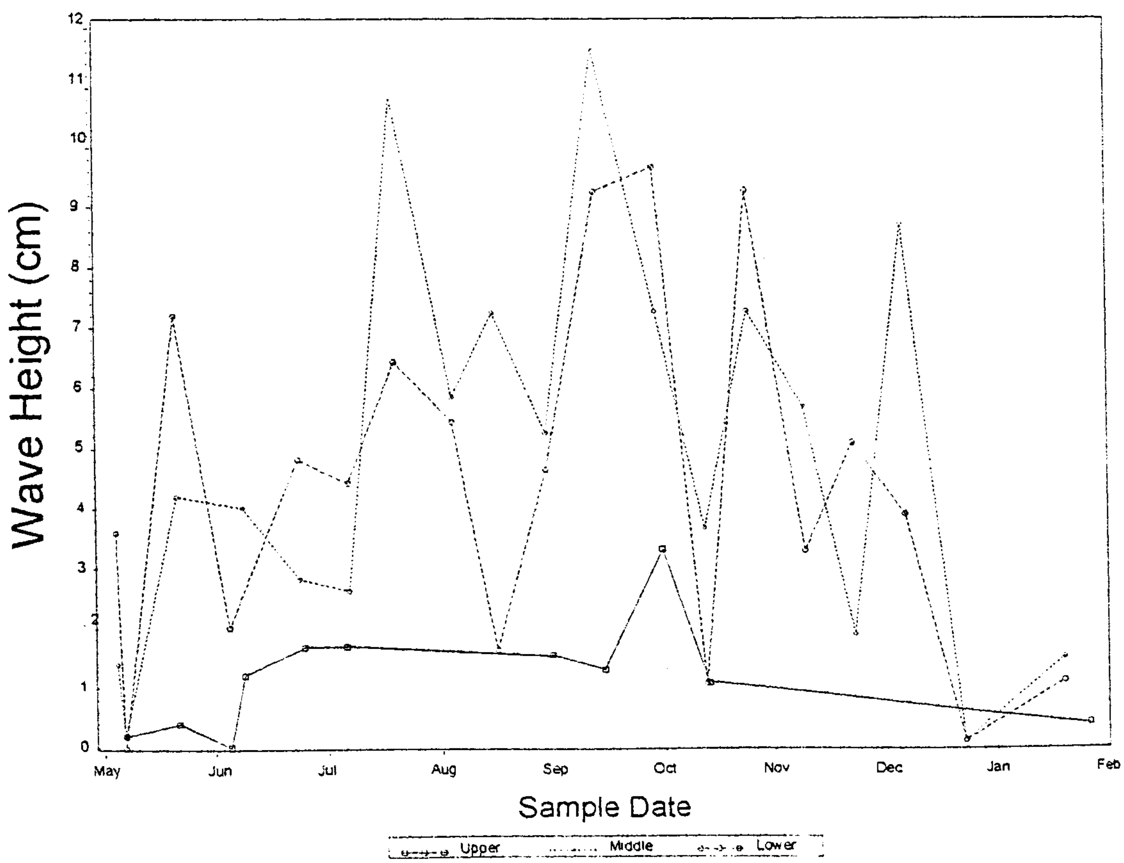


Figure 17. Average bi-weekly wind speed (m/sec.) and wave height (cm) at transect stations in Swan Lake, from May, 1992 to February, 1993.

Table 5. Wind Speed (m/sec) at transect stations in Swan Lake May, 1992 to February, 1993.

	Lower Unit		**Middle Unit**		**Lower Unit**	
	Average	Range	Average	Range	Average	Range
May	0.91	.0-2.3	0.55	.0-1.7	0.48	.0-1.8
June	1.37	.0-3.8	2.10	.4-3.4	1.68	.0-3.2
July	2.01	.0-3.3	1.84	.0-3.7	1.53	.6-2.3
August	1.55	.0-3.4	2.47	.7-3.7	*	*
September	2.96	1.7-4.0	3.61	2.2-5.6	1.08	.0-2.6
October	2.72	.0-6.1	2.76	.9-5.6	1.26	.0-3.3
November	2.59	.7-4.6	2.54	1.1-4.4	*	*
December	2.44	1.7-3.5	1.80	.4-3.1	*	*
January	0.44	.0-1.1	0.44	.0-1.1	*	*
February	0.42	.0-1.0	0.84	.4-1.4	1.10	.3-1.7
Totals	1.74	.4-3.3	3.70	.6-3.0	1.18	.4-2.5

*=sample not taken

Table 6. Wave Height (cm) at transect stations in Swan Lake May, 1992 to February, 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	1.80	.0- 5.0	0.80	.0- 2.0	0.20	.0-1.0
June	4.60	2.0- 8.0	4.13	3.0- 5.0	0.67	.0-4.0
July	4.60	2.0- 7.0	2.70	2.0- 4.0	1.67	.0-3.0
August	4.47	1.0-10.0	7.93	4.0-14.0	*	*
September	6.90	2.0-10.0	8.40	3.0-15.0	1.33	.0-2.0
October	5.30	1.0-14.0	5.40	3.0-10.0	2.29	1.0-6.0
November	6.20	1.0-10.0	6.40	4.0- 8.0	*	*
December	4.40	2.0- 8.0	5.20	1.0-13.0	*	*
January	0.0	* *	0.0	* *	*	*
February	1.0	1.0- 1.0	1.40	1.0- 2.0	0.29	0.0-1.0
Totals	4.36	1.5- 8.1	4.71	2.6- 8.1	1.08	1.0-2.8

*=sample not taken

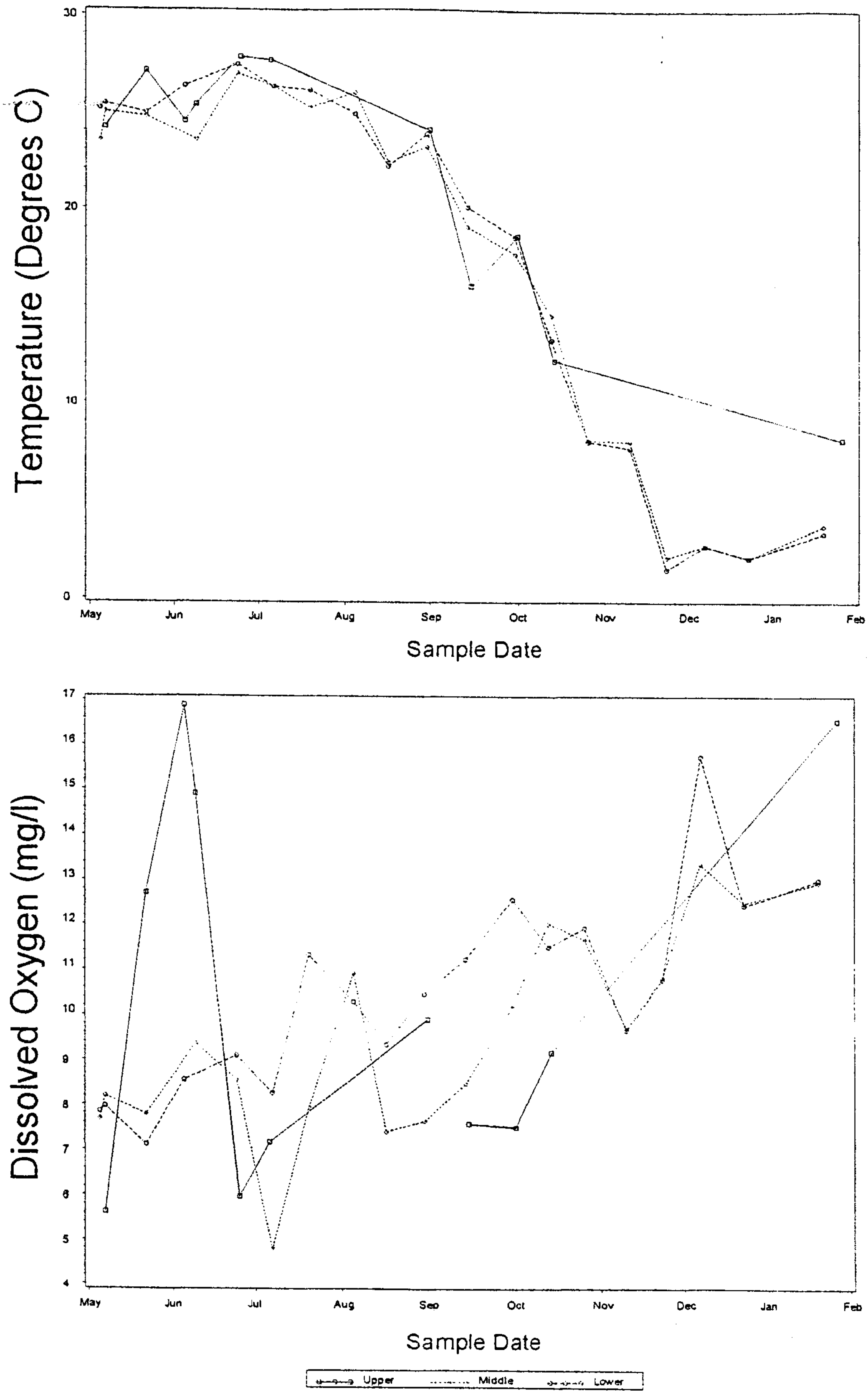


Figure 18. Average bi-weekly temperature (^{0}C) and dissolved oxygen (mg/l) at transect stations in Swan Lake, from May, 1992 to February, 1993.

Table 7. Temperature (^{0} C) at transect stations in Swan Lake May, 1992, to February, 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	25.28	25.0-26.0	24.26	23.0-25.0	24.20	23.8-24.7
June	25.63	24.5-26.8	24.29	23.2-25.5	25.94	23.5-27.9
July	26.86	26.0-27.8	26.63	25.5-27.9	27.75	27.5-18.0
August	24.35	22.0-26.5	24.5	22.0-26.5	*	*
September	21.90	20.0-24.0	21.05	19.0-24.0	18.65	14.8-24.0
October	15.84	12.5-19.1	16.04	13.2-18.5	15.79	11.6-19.0
November	7.73	7.1- 8.6	7.93	7.8- 8.1	*	*
December	2.00	1.2- 2.6	2.31	2.0- 2.6	*	*
January	1.98	1.9- 2.0	1.98	1.9- 2.0	*	*
February	3.26	3.0- 3.8	3.64	3.2- 4.0	8.00	7.0- 9.0
Totals	15.48	14.3-16.7	15.26	14.08-16.4	20.05	18.0-20.4

*=sample not taken

Table 8. Dissolved oxygen concentration (mg/l) at Swan Lake Transects, May 1992-February 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	7.9	7.0-10.0	7.9	6.2-11.4	5.6	4.0-8.4
June	7.8	6.0-9.6	8.4	6.0-9.8	14.3	9.2-20.0
July	8.7	7.9-9.6	6.7	4.2-9.8	6.6	3.0-8.0
August	10.3	7.9-15.9	8.8	6.0-13.0	*	*
September	10.9	8.8-13.2	8.1	6.6-9.5	8.4	2.7-10.8
October	12.1	10.5-14.2	11.1	8.7-13.2	8.2	5.0-10.2
November	10.8	9.3-12.5	10.7	9.1-13.5	*	*
December	13.3	10.2-17.0	12.1	10.6-14.8	*	*
January	12.4	12.2-12.6	12.5	12.1-14.0	*	*
February	13.0	12.5-13.4	13.0	12.6-13.7	16.6	15.4-17.4
Totals	10.6	6.0-17.0	9.6	4.2-14.8	11.1	2.7-20.0

*=sample not taken

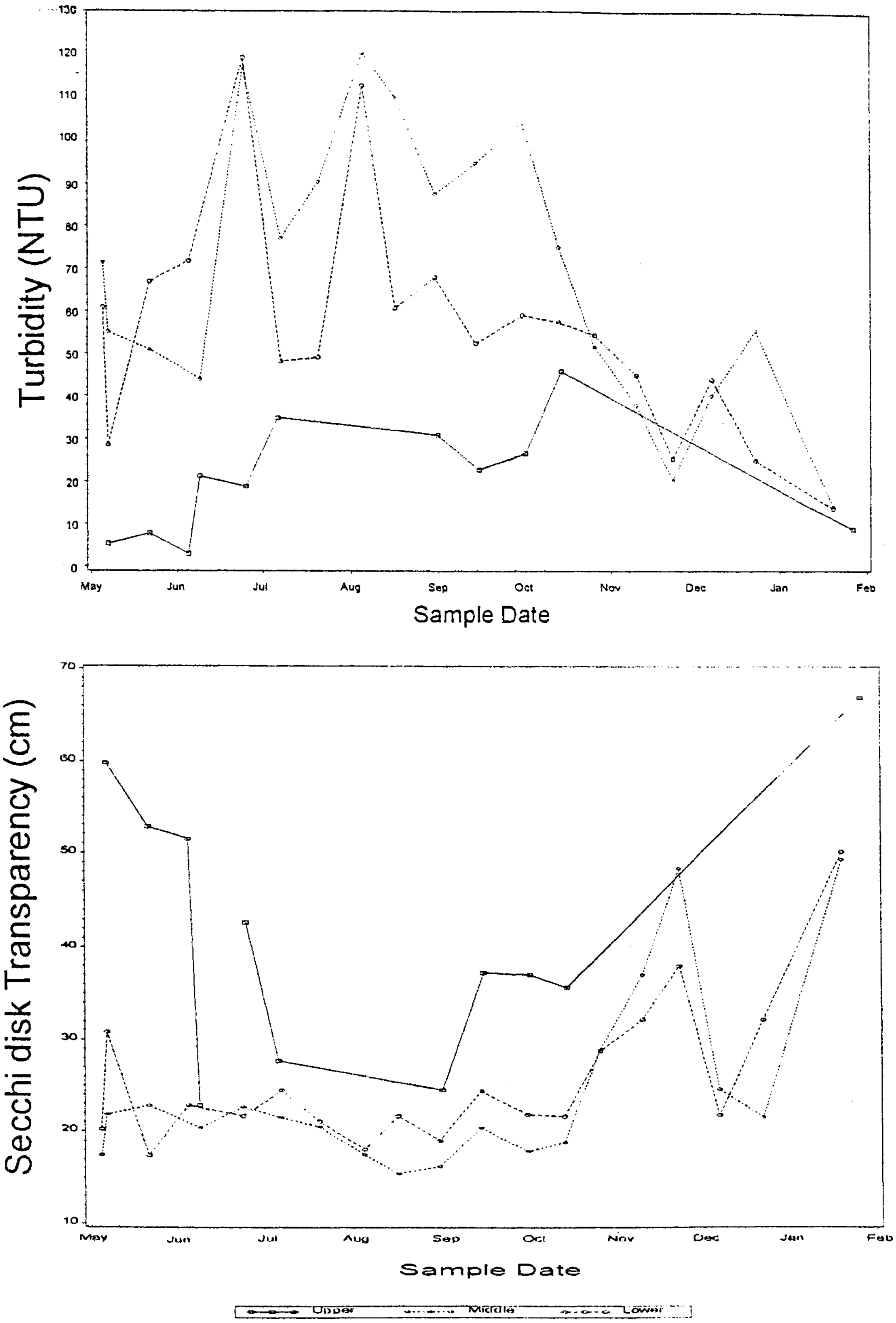


Figure 19. Average bi-weekly turbidity (NTU) and secchi disk transparency (cm) at transect stations in Swan Lake, from May, 1992 to February, 1993.

Table 9. Turbidity (NTU), at Swan Lake transects May 1992 - February 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	44.7	24-82	63.3	44-96	5.4	3-9
June	69.4	57-92	48.4	40-76	12.7	2-56
July	84.1	32-167	97.4	72-170	27.0	6-45
August	74.4	40-147	107.3	74-193	*	*
September	60.3	47-77	91.3	70-153	25.7	11-51
October	58.4	45-78	89.9	68-160	35.0	2-64
November	49.8	37.61	44.9	28-76	*	*
December	34.8	18-73	30.4	19-57	*	*
January	25.2	21-29	55.6	38-81	*	*
February	14.0	11-16	14.4	12-17	9.0	5-14
Totals	56.1	11-167	70.1	12-193	18.0	2-64

*=sample not taken

Table 10. Secchi disk transparency (cm) at Swan Lake transects May 1992-February 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	25.5	15-33	19.6	16-25	*	*
June	20.1	13-26	21.9	18-26	16.5	11-22
July	23.0	15-38	22.0	15-26	35.2	24-49
August	20.2	15-25	17.7	15.25	*	*
September	21.7	18-28	18.3	15-24	35.4	26-57
October	21.7	18-28	18.3	16-22	36.4	28-56
November	30.5	24-34	33.0	26-40	*	*
December	29.9	19-43	36.5	21-51	*	*
January	32.2	31-33	21.6	14-24	*	*
February	50.2	41-62	49.4	40-57	68.0	66-70
Totals	25.7	13-62	24.4	14-57	39.5	11-70

*=sample not taken

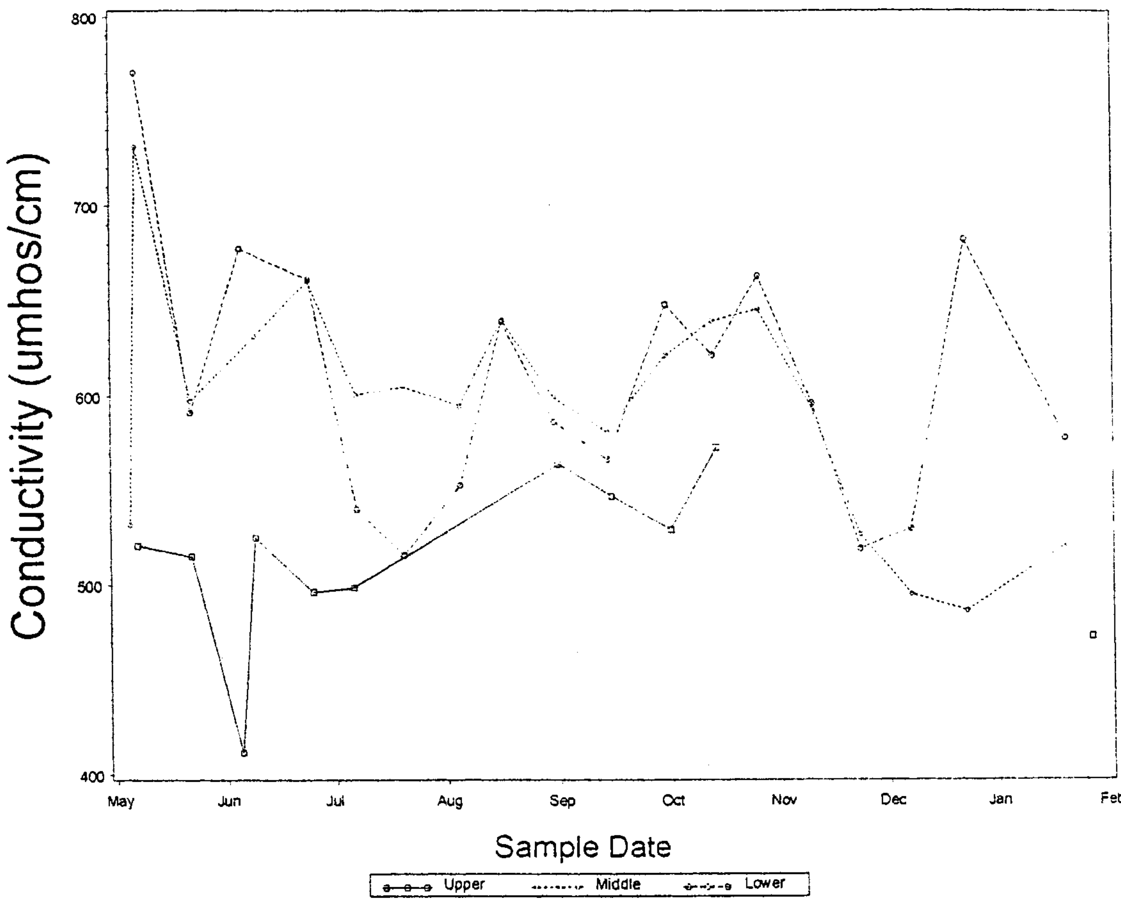


Figure 20. Average bi-weekly conductivity (umhos.cm) at transect stations in Swan Lake, from May, 1992 to February, 1993.

Table 11. Conductivity (umhos/cm) at Swan Lake transects, May 1992 - February 1993.

	Lower Unit		**Middle Unit**		**Upper Unit**	
	Average	Range	Average	Range	Average	Range
May	770.4	560-911	631.9	524-850	521.2	511-537
June	634.5	529-691	610.4	589-647	502.3	409-649
July	600.8	517-682	630.4	595-667	497.5	476-518
August	569.3	509-662	613.1	584-656	*	*
September	576.4	555-602	590.0	576-604	552.8	478-585
October	634.5	598-672	630.3	615-645	548.0	491-612
November	629.4	585-691	622.0	588-650	*	*
December	524.4	484-550	510.9	488-544	*	*
January	682.0	671-693	485.8	476-489	*	*
February	577.2	513-630	521.0	505-536	471.8	464-483
Totals	608.0	484-911	594.0	476-850	511.0	409-649

*=sample not taken

Sediment Investigations

Introduction:

Sediment resuspension by wind generated waves was a major factor considered in the design of the Swan Lake HREP. The construction of a perimeter levee and pump system surrounding the entire lake is included in the project design to provide complete drawdown capabilities to consolidate flocculent sediments. Sediment consolidation during the first year following project completion is expected to improve water clarity in years that drawdowns are not scheduled. The initial water level/sediment management plan is to have complete drawdowns annually in the upper unit, partial drawdowns annually in the middle unit, and stable water levels in the lower unit. Complete drawdowns of the entire lake are scheduled every eight years.

Studies conducted during 1992 included sediment hardness measurements, sediment deposition investigations, and continuous above and below water light comparisons. Mapping of delta expansion will be conducted using GIS and survey methods before and after the project has been in place for 10 years. These methods were determined inadequate to provide all the information necessary to assess project related changes in sediment composition. Studies were expanded in 1994 to include sediment nutrient, sediment deposition, and improved sediment hardness analyses (James et al. in review).

Methods:

Sediment Hardness

Sediment hardness was determined at randomly selected sites in each unit (Fig. 21) with a crude sediment penetrometer constructed from aluminum conduit mounted vertically on a base plate that prevents the device from sinking in the sediment. A small pipe with a hook to suspend a five-pound weight slid inside a larger diameter pipe to a depth determined by sediment hardness. Sediment hardness was measured as the depth in cm that the conduit penetrated the sediment. Measurements were repeated 15 times at most locations, but only 3 times at some sites where sediments were more uniform. Station averages and standard error of the mean are summarized in Table 12.

Sediment Deposition

Sediment deposition studies were conducted to estimate sediment resuspension in relation to the location of proposed island groups (Fig. 21). While impossible to separate river and lake sediments, studies were conducted away from the mouth of the lake during low flow periods to minimize river influences. Sediments were collected in PVC pipes held vertically in a frame containing four chambers (Fig. 22). Chambers had a 3:5 diameter to height aspect ratio recommended in Hakenson (1983). One sample frame was located upstream and another downstream of the proposed island group. Samples were collected between July and November, 1992 when water levels were low.

Sediments were transferred to the lab and allowed to settle while refrigerated prior to decanting overlying water. Wet sediments were weighed then dried at 105^0 C to a constant weight to determine soil moisture content. Dried sediments were then burned at 550^0 C to estimate organic content of the settled sediments. Gross sedimentation (g dry wt./m^2/day) is reported as the average from the four replicate samples at each sample station (Table 13).

Light Penetration

Continuous recording Waterloggers were used to compare light penetration over long periods to model relationships between light penetration, wind speed, and wave height. An above water light sensor recorded ambient light and an underwater sensor recorded light penetration. The Waterloggers were to sit in-situ for several months at a time, but unavoidable equipment problems ended the studies early.

Results and Discussion:

Penetrometer Studies

Penetrometer measurements were completed at 12 randomly selected sites in the lower unit, 2 in the middle unit, and 15 in the upper unit (Table 12). Sediment penetration averaged 6.29 cm (std. deviation $\pm$ 10.38) in the upper unit. A single station in the deepest end of the lake was an outlier by almost 40 cm compared to the other stations that are exposed more frequently.

Sediments were much less firm with average penetration depths more than five times the average in the upper unit. Sediments appeared uniform in the lower unit of the lake, so the middle unit was sampled less intensively.

Sediment Deposition

Sediment sampling targeted a low water period between July and November, 1992 before river stages rose and sediments were likely to have been washed in from the river. The method made the assumption that river inputs were negligible during low water and all suspended sediments were attributable to in-lake sources resuspended by waves. Moisture content of settled sediments (79%; Table 13) was slightly higher than sediment moisture content (68%) measured by James et al. (in review). Organic content of 11% appears slightly lower than those estimated from the long term averages at the LTRMP sites. The daily estimate, 104 $g/m^2/day$, when annualized is almost 50 times higher than the annual accretion rate (790 $g\ m^{-2}y^{-1}$) estimated by James et al. (in press). The difference is a result of in-lake wind and wave induced sediment disturbance.

Light Penetration

Light studies using the Waterloggers was to coincide with activities at the sediment deposition stations, but attempts to complete the modeling effort were unsuccessful due to equipment failures in the field. Microbial slime occluded the underwater sensor rendering them useless after only three days in the water (Figs. 23 and 24). Formalin was applied to the sensors but that only delayed microbial growth. Waterlogger 1 was cleaned and poisoned at weekly intervals, but repeatedly developed a slime that gradually occluded the sensor (Fig. 22). The other Waterlogger was only cleaned and became occluded much faster.

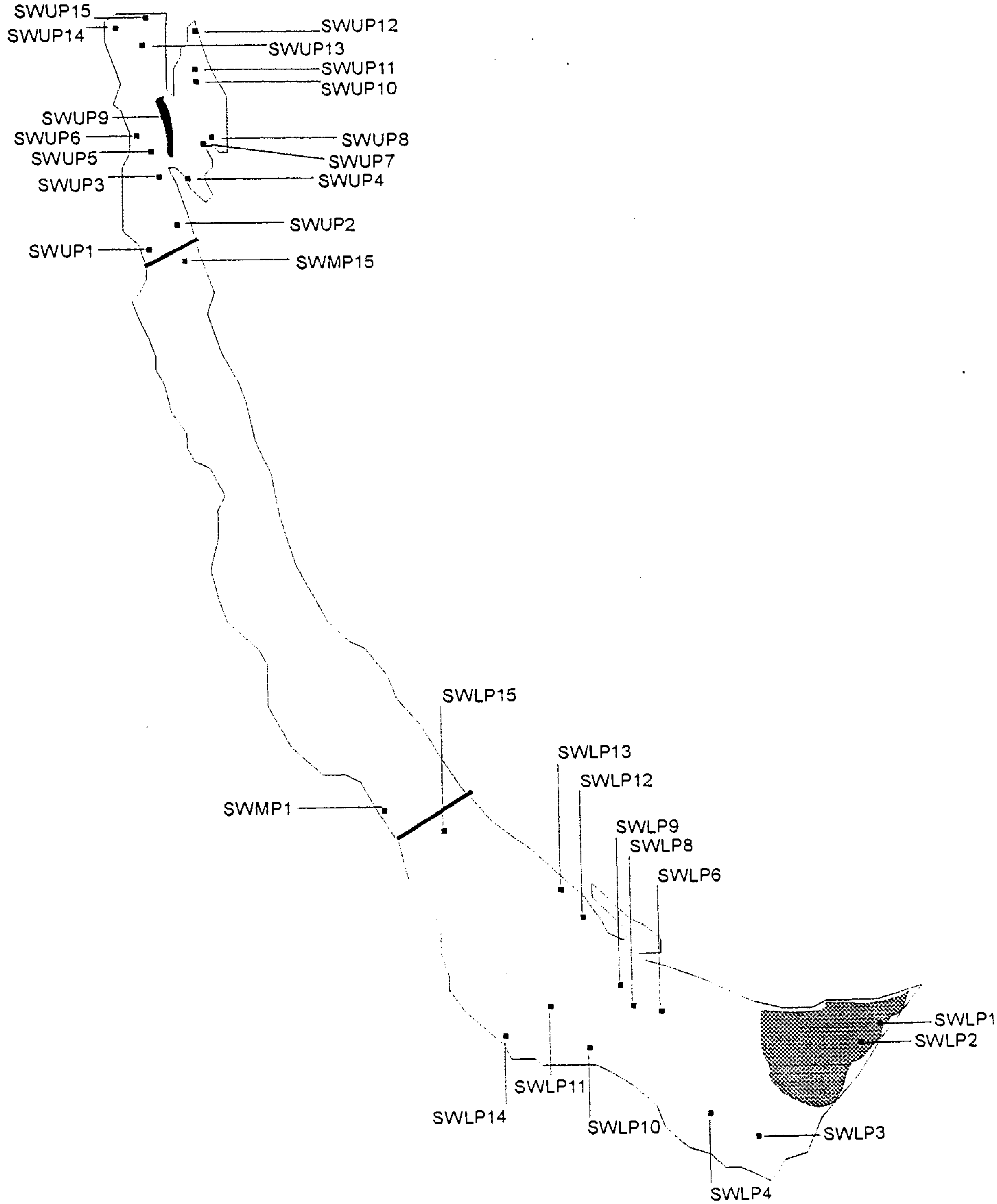
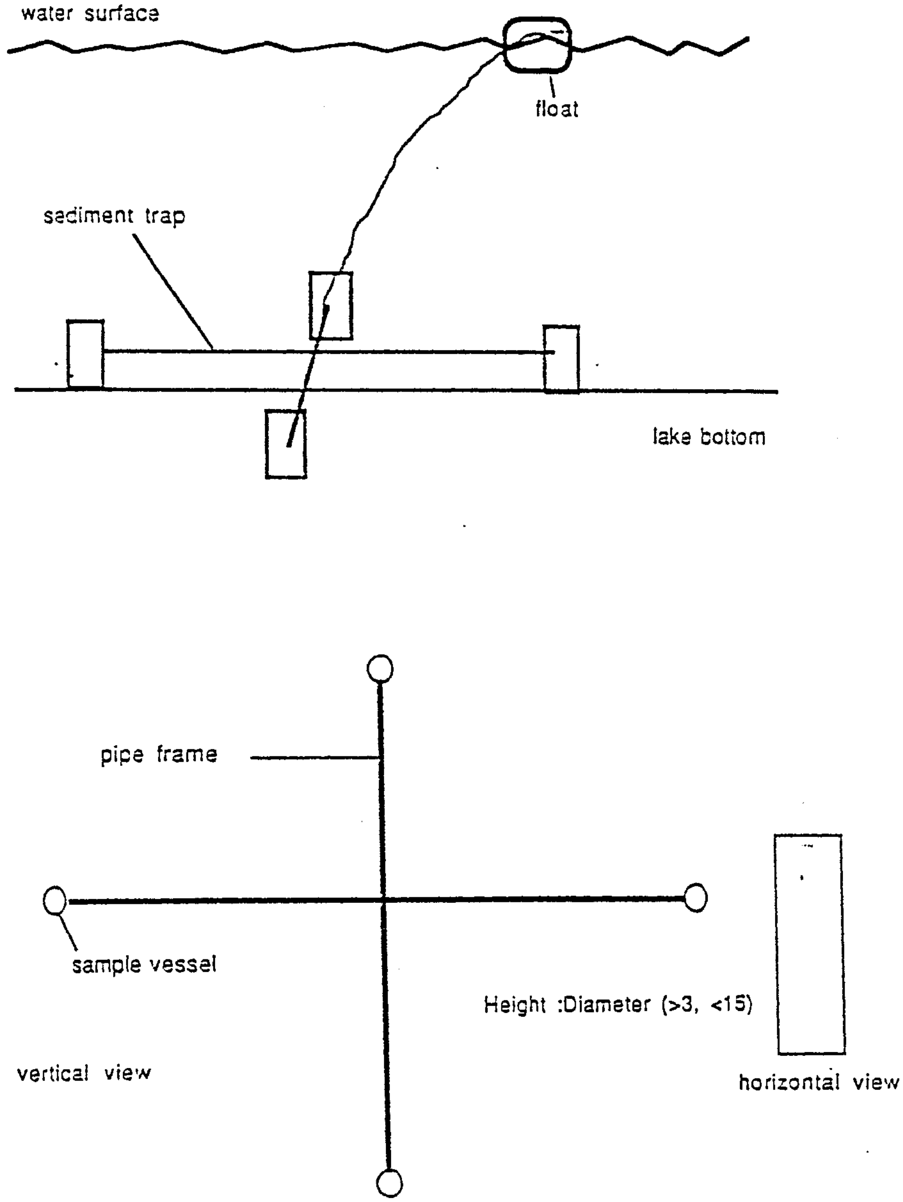


Figure 21. Sediment penetrometer (SWXP#) and Waterlogger/sediment trap stations in Swan Lake.



Generic representation of a sediment trap. Dimensions for Swan Lake traps will be determined during construction.

Figure 22. Schematic representation of sediment trap frame.

Table 12. Average sediment penetrometer measurements in Swan Lake. N=number of replicates at each site, (std error)=standard error of the mean.

Station	N	Sediment Depth (std error)
Lower Swan Lake		
SWL1	15	25.93(1.44)
SWL2	15	32.87(1.89)
SWL3	15	30.47(2.08)
SWL4	15	35.33(0.92)
SWL6	15	39.20(3.18)
SWL8	15	33.53(2.48)
SWL9	15	31.33(1.42)
SWL10	15	38.33(2.10)
SWL11	15	31.67(2.83)
SWL12	15	37.07(2.03)
SWL13	15	40.40(3.03)
SWL15	15	31.47(1.53)
Middle Swan Lake		
SWM1	3	31.00(2.52)
SWM15	15	39.53(2.71)
Upper Swan Lake		
SWU1	15	43.27(2.18)
SWU2	15	8.00(1.78)
SWU3	15	4.80(0.79)
SWU4	3	4.33(0.88)
SWU5	3	1.33(0.33)
SWU6	3	4.33(0.67)
SWU7	3	5.33(1.33)
SWU8	3	1.67(0.33)
SWU9	3	3.33(0.33)
SWU10	3	2.67(0.67)
SWU11	3	2.33(0.33)
SWU12	3	5.33(0.88)
SWU13	3	3.00(0.58)
SWU14	3	2.33(0.33)
SWU15	3	2.33(0.33)

Table 13. Percent moisture, percent organic content, gross sedimentation (g dry wt/m2/day), and their respective standard error of the mean for sediment trap data collected in Lower Swan Lake.

Date	Sampler	Average Moisture (std. err.)	Average Organic (std. err.)	Gross Sediment (std. err.)
07/27/92	1	0.77(0.01)	0.18(0.05)	97.82(10.87)
07/27/92	2	0.79(0.04)	0.07(0.05)	76.38(7.01)
08/10/92	1	0.82(0.01)	0.09(0.00)	70.30(9.44)
08/10/92	2	0.85(0.01)	0.09(0.00)	104.95(18.31)
08/24/92	1	0.78(0.01)	0.11(0.03)	76.16(3.27)
08/24/92	2	0.77(0.00)	0.13(0.01)	67.71(2.98)
09/08/92	1	0.78(0.01)	0.11(0.00)	105.72(12.14)
09/08/92	2	0.79(0.01)	0.11(0.00)	170.74(13.92)
09/21/92	1	0.77(0.01)	0.11(0.00)	105.51(17.89)
09/21/92	2	0.78(0.01)	0.10(0.00)	123.86(5.21)
10/05/92	1	0.79(0.00)	0.11(0.00)	92.93(7.40)
10/05/92	2	0.79(0.00)	0.10(0.00)	100.56(7.31)
10/20/92	1	0.75(0.01)	0.09(0.00)	156.51(18.33)
10/20/92	2	0.76(0.00)	0.00(0.00)	116.74(18.39)
11/09/92	1	0.78(0.00)	0.09(0.00)	121.61(8.25)
11/09/92	2	0.80(0.00)	0.10(0.00)	91.82(2.55)
All Dates		0.79(0.03)	0.11(0.04)	104.14(33.76)

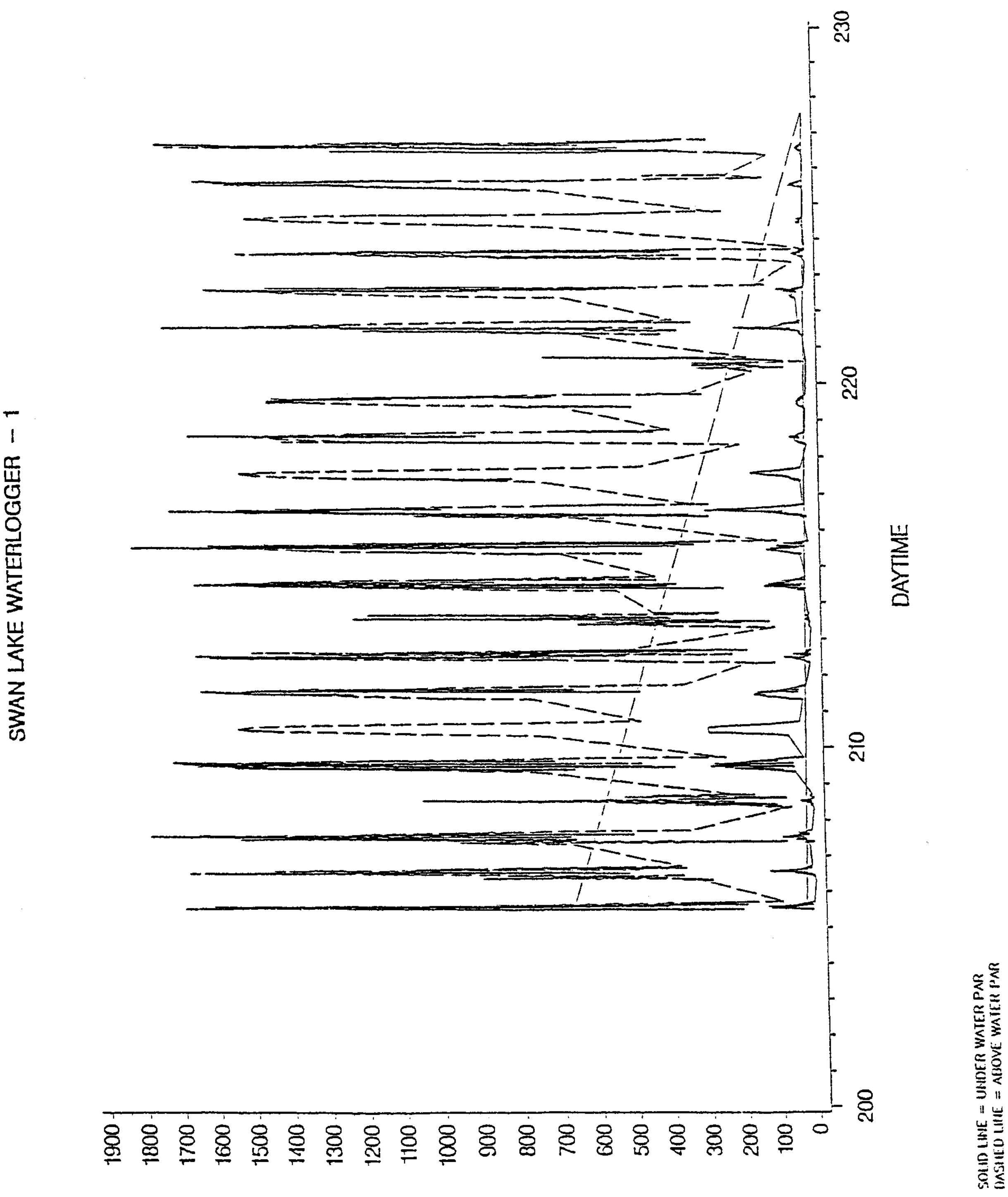


Figure 23. Waterlogger (station 1) above and below water light sensor data collected in August, 1992.

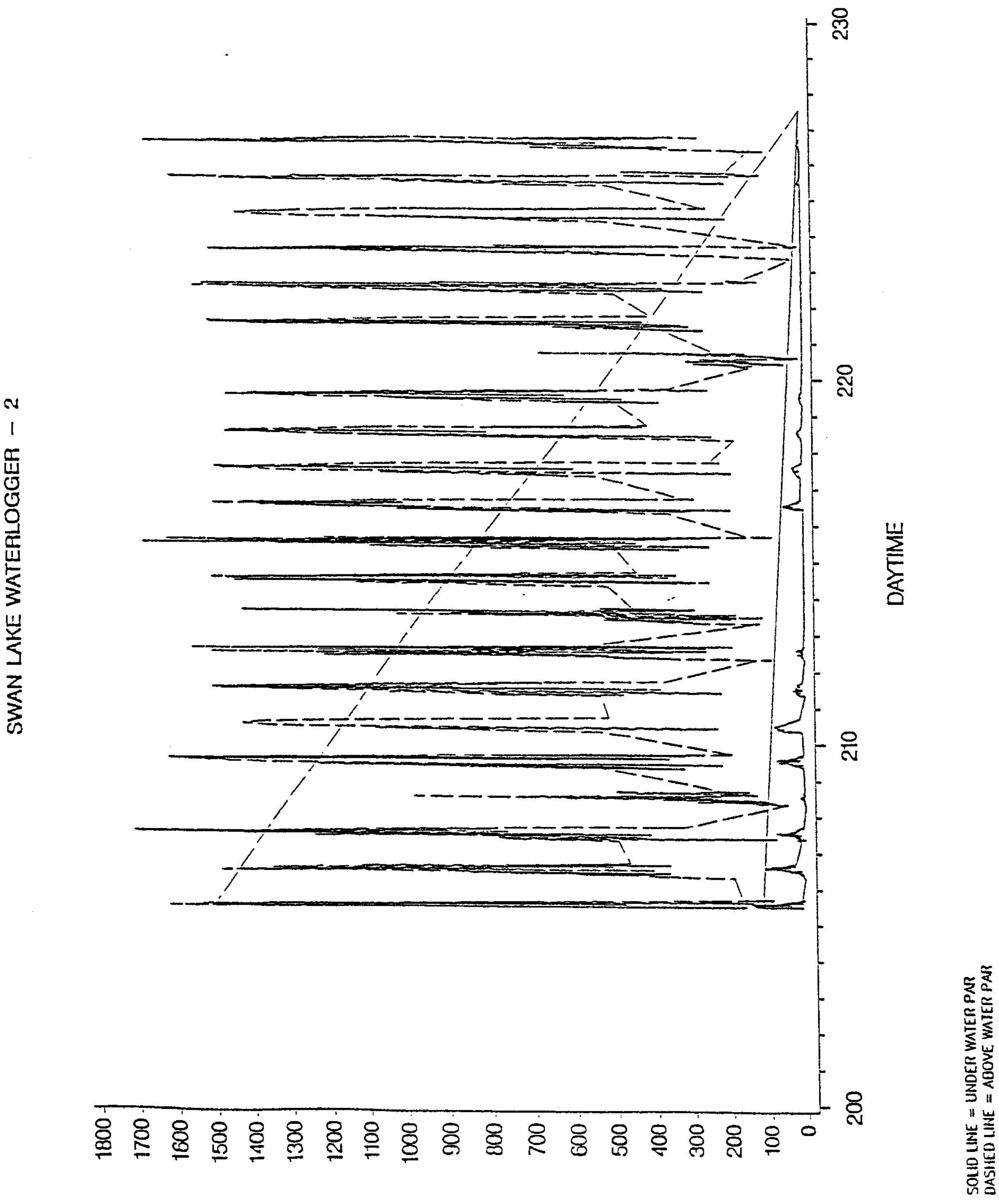


Figure 24. Waterlogger (station 2) above and below water light sensor data collected in August, 1992.

Plant Community and Biomass Investigations

Introduction:

Plant studies were conducted as a cooperative effort between LTRMP Pool 26 Field Station vegetation monitoring and biomass studies conducted for the HREP investigation. Because many features of the project provide water level and sediment management capabilities designed to improve conditions for submersed and emergent aquatic plants, plant investigations were considered critical in the biological response monitoring program. Plant response may be the earliest and most easily quantified response to project completion; a combination of aerial photography, GIS, transect sampling, and biomass data will provide a solid record of plant responses.

The lake currently lacks submersed aquatic vegetation except in the lower unit at the proximity of the connection to the river and in the upper unit when it is not drawn down during the growing season (Fig. 1). Lower and middle unit shorelines are fringed with a narrow band of emergent aquatic plants that survive in a zone subject to frequent changes in water levels caused by discharge and dam operation. Water levels in the upper unit are drawn down to promote emergent aquatic plants on the gradually sloping shoreline.

Post-project water level management plans will strive to promote emergent aquatics in the upper unit, submersed and emergent aquatics in the middle unit, and submersed aquatics in the lower unit.

Methods:

GIS

Aerial photos were taken by the EMTC and transferred to the Pool 26 field station for interpretation and ground truthing. Terrestrial vegetation was delineated as polygons according to the classifications maintained by the LTRMP. Polygons were digitized at the NBS National Ecological Research Center (NERC), Fort Collins, Colorado. Coverages are maintained by the EMTC (LTRMP procedures manual, working draft).

Submersed Aquatics

Transects established to document species composition and relative abundance in established submersed aquatic plant beds was conducted early (May/June) and late (August/September) in the growing season (Fig. 25). Sampling was conducted along pre-established transects at 15 m intervals. A long rake was placed on the bottom and rotated at three spots at each interval. Species composition, relative occurrence, and relative abundance was estimated from rake samples using the LTRMP ranking system (LTRMP Procedures Manual, working draft).

Biomass

Sampling for plant biomass estimates was completed in late June because the sago pondweed bed in the lower unit has a history of disappearing in July. Three samples were collected at 10 and 5 randomly selected stations in established plant beds in the lower and upper unit respectively (Fig. 25). Three samples from each station were collected from a 0.25 m^2 frame tossed randomly behind the surveyor's back. Plants were returned to the lab, spun in a salad spinner, separated by species and above and below ground parts (if possible), weighed, and dried to a constant weight at 105^0C.

Results and Discussion:

Land Cover

Most of the Swan Lake National Wildlife Refuge is composed of open water (Swan Lake) and agricultural lands (Fig. 1, Table 14). Agricultural activities are conducted by local farmers contracted to leave a portion of the crop available for wildlife. The next most abundant class is the woody terrestrial, or floodplain forest, class that surrounds much of the lake to the edge of the crop plots. Grasses/forbs are confined to higher elevations that are not in crops or forest cover. Emergent/grasses/forbs and emergent aquatics typically grade toward open water habitats to form a group that spans a narrow elevation gradient controlled by the dam or management activities. Most annual aquatic and moist soil species occur in managed areas. Submersed aquatic plants are confined to the plant beds near the mouth of the lake and in the upper unit.

Transect Sampling - Submersed Aquatics

Submersed aquatic plants were sampled along transects established by the LTRMP. Species percent occurrence and percent frequency along the transects are presented in Table 15. Sago pondweed was the most common species in the lower unit and accounted for all submersed aquatic plants found during early growing season sampling. Najas species developed later in the growing season, but Sago pondweed maintained dominance of the community. Coontail (Ceratophyllum demersum) appeared in trace amounts in the second sample period.

The upper unit had more species present and all stations sampled had some submersed aquatic plants, as opposed to the bare patches in the lower unit. Bushy pondweed was the most abundant species (32% occurrence), but was mostly found in the rare and occasional category. Coontail was second most abundant; it was rare at 44% of the stations, occasional at 33% and common or abundant at 11% of the station respectively. In decreasing order of abundance, Najas sp. Sago pondweed, Horned pondweed, Water primrose, and Water star grass appeared in decreasing order of occurrence.

No submersed aquatic plants were found in the upper unit during the late growing season sampling period because of drawdowns.

Biomass Estimates

Biomass estimates from the two areas containing submersed aquatic plants were essentially equal (Table 16). Average above ground biomass was 15.5 g dry wt/m^2 in the lower unit, and 20 g dry wt/m^2 in the lower unit. Below ground biomass consisted almost entirely of sago pondweed tubers. Below ground biomass was 0.70 g dry wt/m^2 in both units, but was only high at a few sites where sago pondweed tubers were present. Our biomass estimates are considerably lower than those from arrowhead and lotus beds in Pool 19 reported by Grubaugh et al. (1986).

Implementation of the HREP should produce marked changes in the distribution of aquatic and emergent plants. Emergent plants should be more abundant in the middle unit due to improved drawdown capabilities. Emergents should appear in the lower unit in drawdown periods, but submersed aquatic are expected to flourish as a result of drawdown effects. Submergent plants are expected to appear in open water habitats because of reduced sediment resuspension and more compact substrates following the complete drawdown.

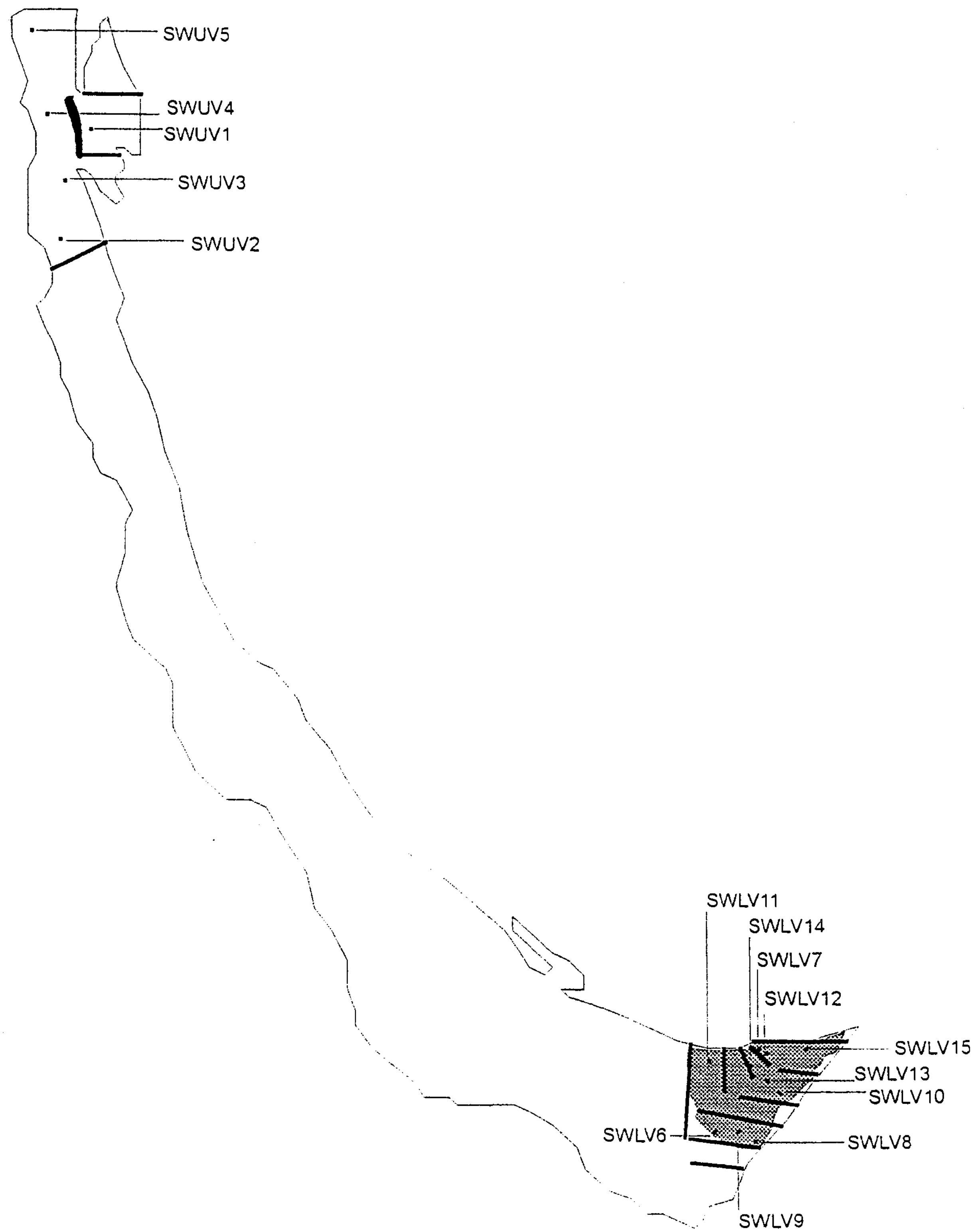


Figure 25. Submersed aquatic plant sampling transects and biomass sample stations in Swan Lake plant beds.

Table 14. Areal measurements (ha and acres) from GIS coverage of the approximate boundaries of the Swan Lake National Fish and Wildlife Refuge. Land cover classes in **bold** print are expected to be influenced by the HREP (Source: LTRMP land cover database)

Land Cover Class	hectares	acres
Open Water	1151	2844
Agriculture	1069	2641
Woody Terrestrial	852	2105
Grasses/Forbs	119	294
Submersed Aquatics	121	299
Rooted Floating Aquatics	12	30
Urban/Developed	21	52
Emergent/Grasses/Forbs	24	59
Emergent Aquatic	14	35
Sand/Mud	6	15

Table 15. Species occurrence and abundance in Swan Lake submersed aquatic plant beds. Frequency ratings: 1 = Rare, 2 = Occasional, 3 = common, 4 = abundant.

Species	Percent Occurrence	Percent Frequency			
		1	2	3	4
Lower Swan - Early					
None	30				
Sago pondweed	70	33	52	14	0
Lower Swan - Late					
Coontail	T				
Najas Sp.	2	17	50	17	17
None	18				
Sago pondweed	80	10	8	20	62
Upper Swan - Early					
Coontail	25	44	33	11	11
Water Primrose	7	100			
Najas sp.	14	40	20	20	20
Bushy pondweed	32	61	30	9	
Sago pondweed	11	63	37		
Horned Pondweed	11	25	13	62	
Water star grass	1	100			

Table 16. Vegetation biomass in Swan Lake samples.

Site	Wet Weight Below Ground	Std Error	Dry Weight Below Ground	Std Error	Wet Weight above Ground	Std Error	Dry Weight Above Ground	Std Error	Percent Vegetated
Lower Swan Lake									
1	2.40	2.40	0.20	0.20	186.00	65.96	22.00	9.19	4.00
2	6.33	3.48	0.00	0.00	29.00	11.93	3.00	1.00	2.00
3	0.00	0.00	0.00	0.00	28.67	18.77	2.00	1.15	1.00
4	0.00	0.00	0.00	0.00	38.33	33.93	2.67	2.19	1.00
5	0.00	0.00	0.00	0.00	79.33	34.17	7.67	2.60	2.00
6	16.33	5.21	1.33	0.33	165.67	32.68	29.00	4.04	4.00
7	17.67	3.93	1.33	0.33	157.33	34.37	21.67	5.84	4.00
8	8.33	4.91	1.00	0.58	86.00	43.00	13.00	6.66	3.00
9	15.67	2.40	1.33	0.33	126.67	26.24	20.00	4.04	4.00
10	6.33	1.67	1.00	0.00	104.00	23.03	16.33	2.33	3.00
Upper Swan/Fuller Lakes									
11	7.33	1.20	6.00	5.00	145.33	58.00	24.50	12.50	4.00
12	8.00	0.58	3.00	2.00	113.67	46.93	18.00	7.94	4.00
13	8.00	3.06	1.00	0.00	89.33	47.13	24.00	7.00	4.00
14	14.67	4.33	1.67	0.33	128.00	30.01	19.00	5.00	4.00
15	9.00	2.31	1.00	0.00	143.33	17.33	23.00	3.46	3.67

Benthos Investigations

Introduction:

Benthic invertebrates provide important links in riverine food webs by transforming plant energy to vertebrate predators. Because invertebrate communities differ in relation to habitat conditions (current, sediment type, plant presence/absence/type), the goal of HREP invertebrate sampling was to characterize benthic invertebrate community composition, abundance, and biomass in the two primary aquatic habitats present in Swan Lake (open water sediments and submersed aquatic plants). HREP goals to increase plant abundance and sediment hardness might influence invertebrate communities in favor of epiphytic invertebrates.

Expansion of plant communities in Swan Lake will likely lead to an expansion of the epiphytic invertebrate community. The smaller, more numerous epiphytic invertebrates may be more productive than larger, longer lived invertebrates in the sediments and therefore provide greater total energy transfer in the system. Small fish are attracted to vegetated habitats for both protection from predation and abundant forage of the appropriate size (Mittelbach 1981).

Sediment consolidation may alter sediments in a manner that eliminates the benthic community dependant on soft silt substrates. If drying and compaction is too severe, benthic communities may be killed outright during the drawdown. Alternatively, sediment hardness might exceed the burrowing capabilities of the benthic community. Benthic and epiphytic invertebrate communities can be highly dynamic and are expected to respond rapidly to project implementation.

Methods:

Benthic Invertebrates

Three ponar dredge samples (529 cm^2) were collected at 15 randomly selected stations in each future lake management unit (Fig. 26). Samples were washed through a U.S. No. 35 sieve (0.5 mm) and stored in 4% buffered formalin. Samples were sorted under 7X magnification in the lab and transferred to alcohol. Taxa were classified to family in most cases to identify major groups in each area. Chironimids were simply split into large (>10 mm) and small (<10 mm) categories to identify large Chronimus sp. common in some samples. A subsample (100 individuals) of the most abundant taxa and as many as available rare taxa were dried 24 hours at 105^0 C to estimate average individual biomass for biomass estimates.

Epiphytic Invertebrates

Epiphytic invertebrates were collected with a 22 cm diameter "stovepipe" sampler designed to slice plants at the sediment interface and hold them until a rinse screen was quickly placed under the sampler. Water was allowed to wash out unscreened from

Page 71 missing from the bound original

upper unit. Epiphytic communities (snails, small chironomids, and cladocera) were confined to plant beds (Table 18).

Abundance and Biomass

Total invertebrate density and biomass is presented for individual sample stations for both plant and benthos samples in each lake unit (Table 19). Distribution within units is uniform except for the lower unit where higher densities and biomass are found farther from the mouth of the lake (stations 9 - 15). Benthos density and biomass was lowest in areas where plants occur during the summer.

Comparisons among habitats sampled are presented in Figure 28. The lower unit had the highest benthic and epiphytic invertebrate biomass and density. The middle unit (no submersed aquatic vegetation) was intermediate in benthos biomass and density. The upper unit (managed for waterfowl) had the fewest and lowest biomass of benthic and epiphytic invertebrates. Nektonic invertebrates were plentiful in flooded emergent plants, but not effectively sampled by the sampling techniques used. Gates and Smietanski (1994) present neckton data in their waterfowl observation report.

Differences in invertebrate communities found among habitats in Swan Lake were not unusual for Illinois River backwater lakes (Gates and Smietanski 1994). It was somewhat surprising to note the low biomass and densities in plant beds and hard substrates, but these are typically smaller and more productive species that may actually contribute more to total lake energy transfer than benthic communities. The results are comparable to results found by Chilton (1990) in Lake Onalaska, Pool 7, Elstad (1986) in Pools 7 and 8, Seagle et al. (1982) in Pool 26, and Anderson and Day (1986) in Pool 26. Production studies are necessary to accurately quantify the relative energetic contribution of individual taxa/groups found in soft substrate habitats.

The distribution of benthos may be explained by predation by fishes. Waterfowl foraging in the lake was very low (Gates and Smietanski 1994) and is not considered a factor to benthic populations, fish, therefore, are assumed to be the major predator. Their high abundance (see next chapter) in the middle unit may explain lower benthic densities. The differences within the lower unit may be a combination of river fish feeding near the opening of the lake and the presence of the plant bed. Fish feeding habits and movements need to be better understood to document the effect of predation on backwater benthos communities.

Though not funded by HREP sources, mussel surveys conducted in 1993 and 1994 have provided documentation of mussel communities in Swan Lake (Tucker and Atwood 1995, Tucker et al. in press). Mussel densities are highest near the mouth of the lake. Species composition shifts from riverine fauna near the mouth to backwater fauna in the interior of the lake (Tucker et al. in press). Zebra mussel densities on mussels in Swan Lake are lower than on mussels in similar river habitats (Tucker and Atwood 1995).

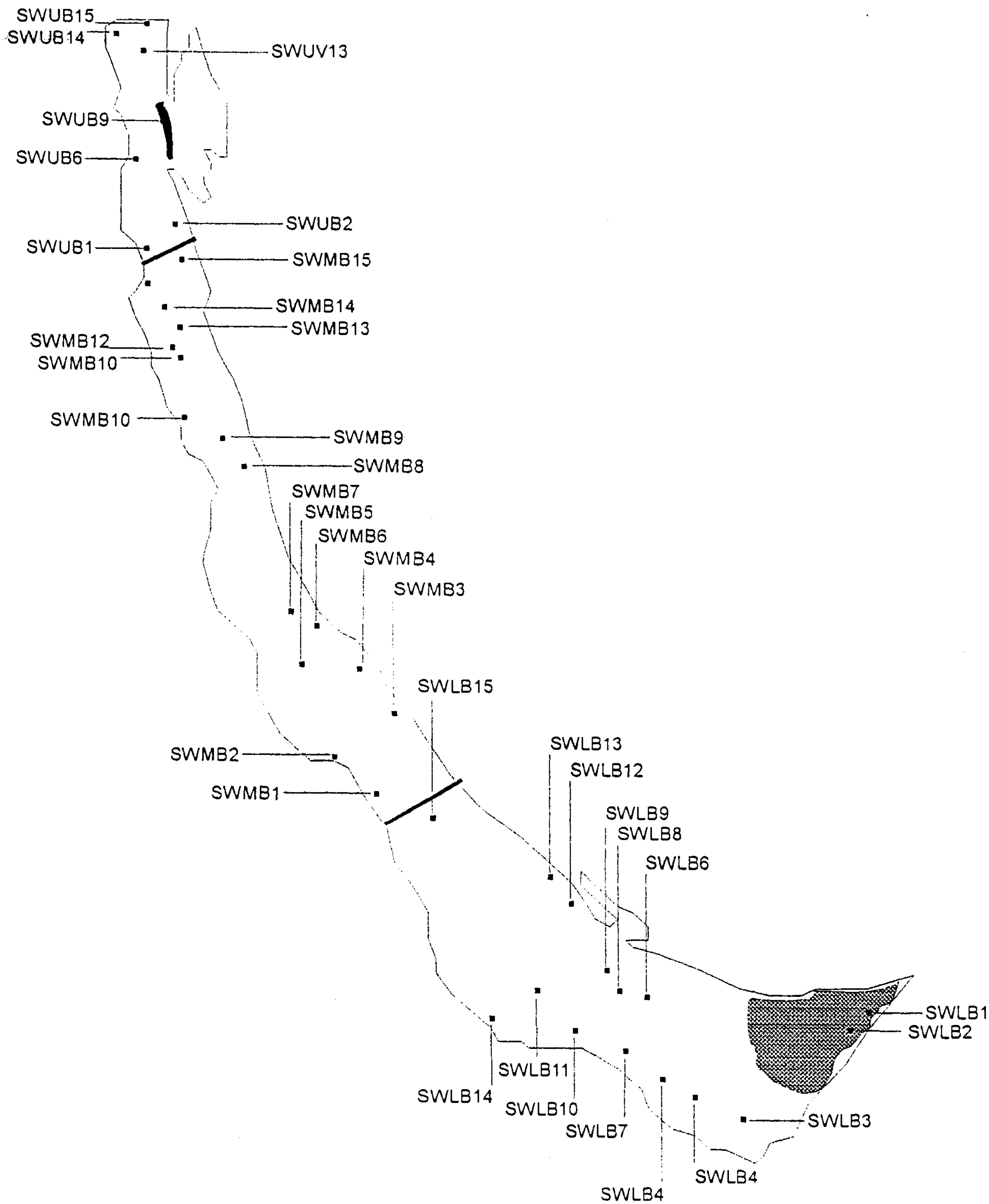


Figure 26. Benthos sample stations in swan Lake, February, 1992.

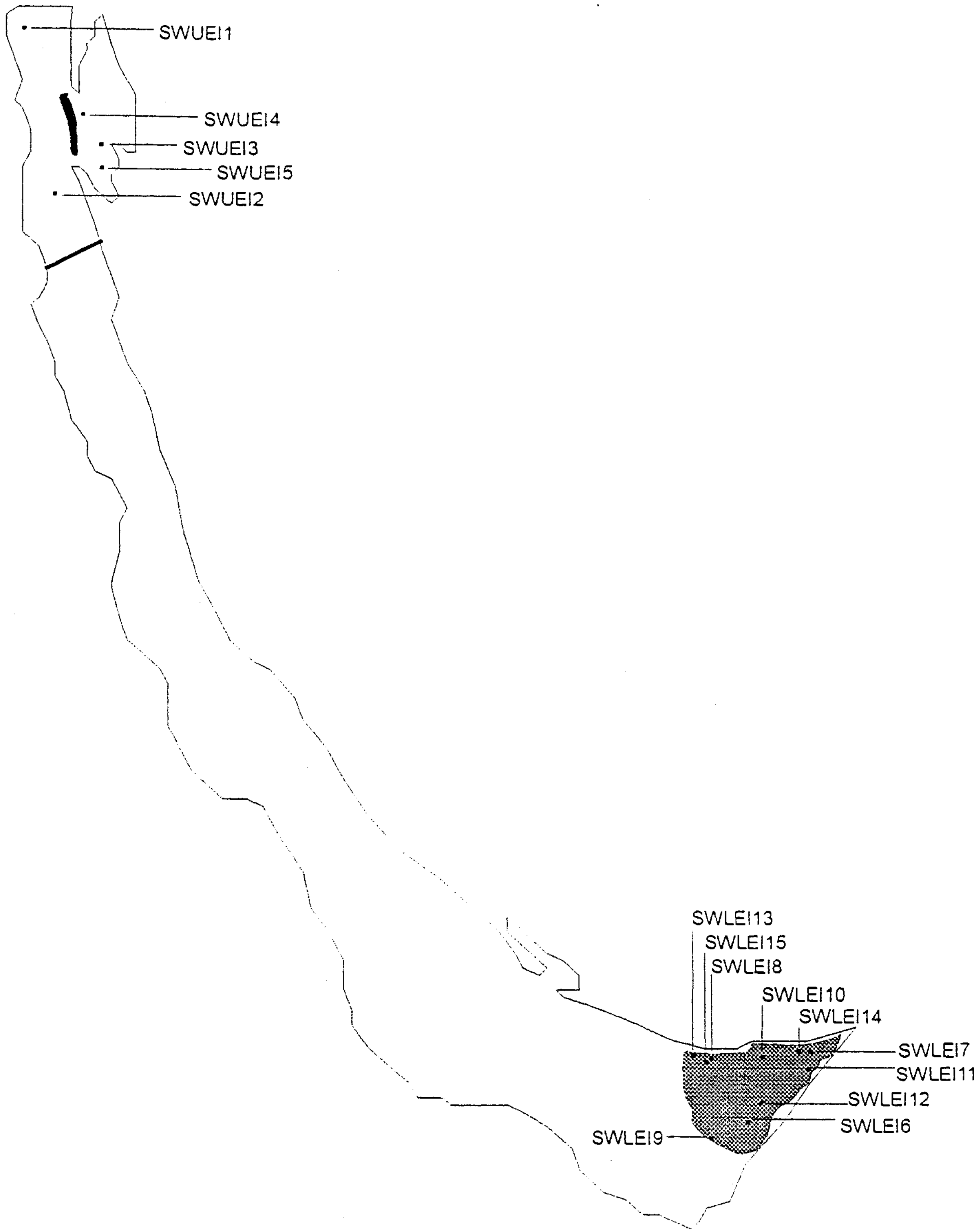


Figure 27. Epiphytic invertebrate sample stations in Swan Lake submersed aquatic plant beds, June, 1992.

Table 17. Invertebrate taxa distribution in Swan Lake benthos and plant samples.

	Sample Area				
	Benthos			Plants	
Taxa	Upper	Middle	Lower	Upper	Lower
Baetis				X	X
Belostamatidae				X	
Berosus	X			X	X
Caenidae			X		
Ceratopogonidae		X	X	X	X
Chironimids					
pupae	X	X	X	X	X
large	X	X	X		
small	X	X	X	X	X
Cladocera	X	X	X	X	X
Copepods	X	X	X	X	X
Corixids	X	X	X		X
Culicids				X	X
Gerridae				X	
Hexagenia			X		
Hirudinea	X	X	X		
Lestidae				X	
Libellulidae	X				X
Microveliidae					X
Oxus		X			X
Snail	X				X

Table 18. Relative Abundance of dominant invertebrate taxa (>5%) in Swan Lake benthos and plant samples.

Taxa	Relative Abundance (%)
Upper Swan - Plants	
Ceratopogonids	9
Cladocera	16
Small Chironimids	35
Snails	15
Lower Swan - Plants	
Chironimid Pupae	10
Small Chironimids	71
Snails	12
Lower Swan - Benthos	
Large Chironomids	41
Small Chironomids	57
Middle Swan - Benthos	
Large Chironimids	39
Small Chironimids	54
Upper Swan - Benthos	
Cladocera	50
Hirudinea	19
Small Chironimids	13
Snails	10

Table 19. Mean invertebrate density and biomass estimate ± 1 standard error for three ponar dredge samples collected at each station in Swan Lake. (EI = plant samples, SWX = benthos samples).

	Sample Station	Density (no.m2)	SE	Biomass (mg dry wt./m2)	SE
Upper Swan - Plants					
	EI1	2579.62	306.02	804.35	26.97
	EI2	1353.50	1130.57	291.72	198.73
	EI3	1019.11	241.14	999.36	751.69
	EI4	1226.11	461.78	259.55	51.27
	EI5	1894.90	1480.89	532.64	441.56
Lower Swan - Plants					
	EI6	11751.59	.	3136.62	.
	EI7	5339.70	149.75	1783.76	117.74
	EI8	10084.93	5184.02	3751.70	1936.84
	EI9	11210.19	4058.85	3452.12	1364.57
	EI10	10573.25	6114.65	3485.99	2133.12
	EI11	8248.41	.	2987.90	.
	EI12	7664.54	2389.34	2351.80	737.25
	EI13	8418.26	1091.10	2550.11	298.22
	EI14	3991.51	1803.83	1557.86	862.95
	EI15	1878.98	.	782.17	.
Lower Swan - Benthos					
	SWL1	236.29	160.68	113.42	36.48
	SWL2	674.23	31.51	799.81	278.10
	SWL3	5129.17	1091.47	2833.14	378.42
	SWL4	2804.03	581.66	2329.93	107.26
	SWL5	5475.74	2350.95	2983.99	714.02
	SWL6	8424.70	1989.14	13706.62	715.15
	SWL7	3509.77	1712.85	1419.53	706.51
	SWL8	8298.68	607.37	9427.79	2784.88
	SWL9	8494.01	1819.25	12343.86	3051.42
	SWL10	8021.42	1374.66	21302.58	3222.81
	SWL11	6981.73	915.30	16804.28	161.57
	SWL12	6801.51	1724.49	10174.33	2711.51
	SWL13	4688.09	749.10	10103.40	1503.85
	SWL15	6528.04	1152.98	13579.65	2893.61
Middle Swan - Benthos					
	SWM1	6814.74	1635.16	11278.07	4736.29
	SWM2	3207.31	1396.24	5318.15	2701.39
	SWM3	3832.70	485.54	5380.62	1752.15
	SWM4	5091.37	109.32	8980.21	1095.75
	SWM5	6030.25	1928.17	13838.66	4595.37
	SWM6	2879.65	224.29	9033.40	684.07
	SWM7	6162.57	296.69	6669.44	418.14
	SWM8	4341.52	642.57	13140.08	2430.95

(Table 19 cont.)

SWM9	6200.38	738.53	2551.92	121.60
SWM10	2805.83	557.10	5076.94	1004.11
SWM11	1102.71	404.01	1501.64	705.45
SWM12	2394.45	435.24	3925.65	446.06
SWM14	3062.38	643.56	1163.71	245.32
SWM15	6351.61	151.23	2739.51	48.99
Upper Swan - Benthos				
SWU1	1427.22	368.62	837.24	239.51
SWU2	1235.03	185.64	681.10	63.96
SWU3	3276.62	2407.68	599.37	214.50
SWU4	869.57	236.36	393.89	66.60
SWU5	1745.43	693.05	669.57	194.96
SWU6	3232.51	1701.46	1471.71	735.93
SWU7	1789.54	1022.91	215.63	123.58
SWU8	1181.47	368.62	281.00	44.52
SWU9	8638.94	.	947.26	.
SWU10	2722.12	2334.75	393.51	144.54
SWU11	951.48	328.39	403.09	203.22
SWU12	176.43	121.70	109.96	61.22
SWU13	775.05	709.41	276.31	239.81
SWU14	415.88	264.65	156.99	115.41
SWU15	296.16	138.20	106.87	55.93

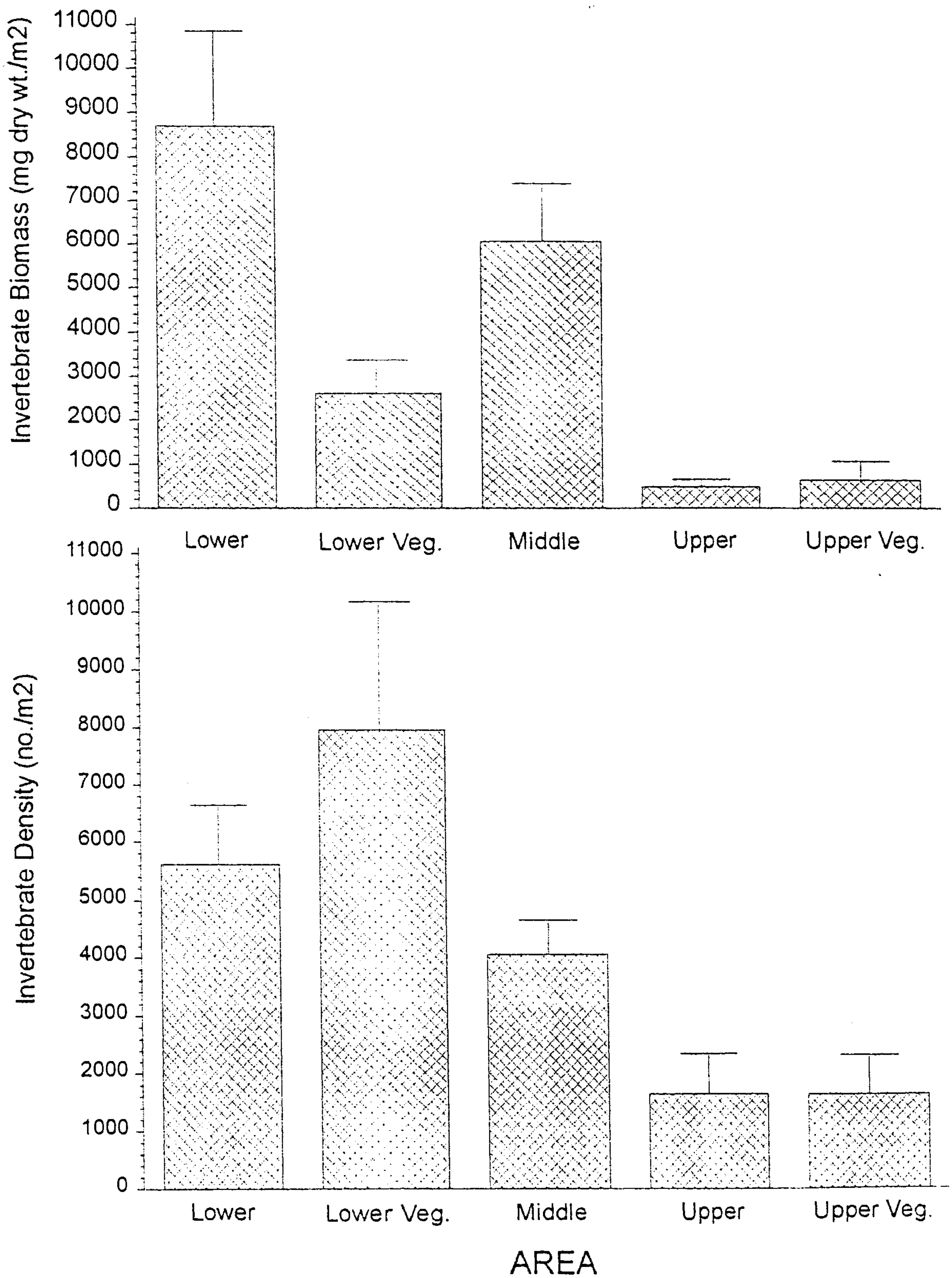


Figure 28. Invertebrate density (no./m^2) and biomass (g dry wt./m^2) ($\pm$ 1 standard error) from benthos and epiphytic invertebrate (veg) sample stations in Swan Lake.

Fish Investigations

Introduction:

Consideration of the HREP's effect on the local fishery was a major obstacle in project planning because the lake was suspected to be an important overwintering (Sheehan et al. 1975) and spawning habitat for river fishes. Water control structures were designed to minimize the impact on fish movements between the river and the lake, but the current opening will be closed except for the water control structures. The objectives of HREP fish community sampling within the lake was to document habitat use by the entire fish community, through a multiple-gear approach, in both summer and winter periods. Subsamples of selected species were aged to evaluate the population age-size structure and compared to earlier estimates. Work by the Cooperative Fisheries Research Laboratory, Southern Illinois University - Carbondale (Sheehan, personal communication) will assess fish movements through both interior and exterior structures in the post-project phase.

Many river fishes are dependant on backwater habitats for certain aspects of their life history needs (spawning, overwintering, rearing; Welcomme 1979). Evidence from prior studies on Illinois river winter fish movements (Sheehan 19??) and commercial fishing tactics in the lake suggest Swan Lake is meeting the needs of many river fishes; including the paddlefish (Shasteen and Maher, unpublished data). This work provided important baseline data on Swan Lake fish communities and within-lake fish distribution that will be necessary to document changes due to the HREP. It is important to note, however, that one year sampling may be an inadequate baseline to document a dynamic fish community.

Methods:

Gear description

Trammel nets were used to sample the larger size classes of fish in the lake. The nets were 300' long with outer panels of 14" bar mesh and an inner panel of 3" bar mesh. All mesh was multifilament nylon. These nets were patterned after nets used by local commercial fishermen and were "dead set" for 24 hours.

Wisconsin style fyke nets were used to sample the intermediate size classes of fishes using the lake. These nets consisted of a 50' X 4.5' lead, two 3' X 6' frames and six, 3' diameter hoops. There were two throats, the front throat was twenty meshes long knitted to forty meshes around, the back throat was twenty-eight meshes long knitted to thirty-two meshes around. All webbing was 3/4" bar of #12 bonded nylon and the entire net was treated with net coat. In the lower and middle units the leads of two nets were tied together and fished in "tandem" for 24 hours. Nets were fished in this manner due to the inability to access the shoreline at a depth sufficient to submerge the throats of the nets. In the upper unit the leads of single nets were staked to the shoreline and fished for 24 hours. This net was constructed to the same specifications as the fyke nets used for the Long Term Resource Monitoring Program (LTRMP Procedures Manual, working draft), thus enabling future comparisons between Swan Lake and other similar habitats on the Upper Mississippi River System (UMRS).

The young-of-the-year fish community was sampled with small Wisconsin style fyke nets. The nets consisted of a 15' X 2' lead, two 2.2' X 4' frames and two 2' diameter hoops. There was one throat with a 2" opening. All mesh was 1/8" ace style and the nets were green dipped. The leads of these nets were also tied together and fished for 24 hours in the lower and middle units. In the upper unit the leads of single nets were staked to shoreline and fished for 24 hours. These nets are also used by the LTRMP, allowing a comparison of the reproductive success of Swan Lake fishes to fishes in other river reaches.

Young-of-the-year fishes were also sampled with a 100' seine, constructed of 1/8" untreated ace style mesh. Seine hauls were made deploying the net perpendicular to shore and making a 90 degree arc back to shore. A limited amount of seining was done due to a lack of suitable sites on gradually sloping shorelines.

Site Selection and Effort Allocation

The lake was arbitrarily divided into the proposed lower, middle and upper units. The upper unit is currently separated from both Swan lake and the river by a low elevation levee. This area is managed by the Illinois Department of Conservation as a waterfowl hunting area. The lower and middle units were designated based on the location of the proposed levee system (Fig. 2). Fisheries sites in the lower and middle units were the same randomly chosen sites used for invertebrate sampling (Fig. 26). Of the thirty sites chosen for invertebrate sampling in the lower and middle units, twenty four were deemed suitable for fisheries sampling. Of these, fourteen were located in the lower unit and ten were located in the middle unit (Fig. 29). A site was deemed unsuitable for fish sampling if the water depth was less than 40 cm (depth necessary to submerge the throats of fyke nets). Due to the lack of suitable sites, three sites were subjectively chosen in the upper unit (Fig. 29). All sites in the lower and middle units were sampled once during the summer and winter periods. The sites in the upper unit were sampled three times in the summer. The upper unit was not sampled in the winter due to conflicts with waterfowl hunters and logistical constraints. A site was sampled with one trammel net set, one tandem fyke net set and one tandem minnow fyke net set during the summer period. During the winter sampling period a site was sampled with one trammel net set and one tandem fyke net set. Seine sites were subjectively chosen at suitable areas and two hauls were pulled at each site. Time periods were selected based on seasonal conditions. The Summer period was from 1 June 1992 - 15 September 1992, the Winter period was from 16 November 1992 - 24 March 1993.

Results:

Species Composition

Fish collected from all our sampling efforts included 40 species (Table 20). The greatest number of species were collected in the lower unit (36) followed by the middle (29) and upper (24) units. Distribution of fishes is discussed more thoroughly for each gear type below.

Species diversity (Table 21) was highest in the lower unit, followed by the middle and upper unit respectively during summer. During winter, species diversity dropped in the lower unit and increased in the middle unit. Higher catch rates and greater species diversity support the hypothesis that fish use the lake as an overwintering habitat and tend to move up the lake and away from the river.

Trammel Net Catch

Summer

A total of thirteen species were collected with trammel nets during the summer period (Table 22). Of these species, spotted gar (*Lepisosteus occulatus*) and largemouth bass (*Micropterus salmoides*) were unique to the upper unit. Species unique to the lower and middle units were shortnose gar (*Lepisosteus platostomus*), channel catfish (*Ictalurus punctatus*), and smallmouth buffalo (*Ictiobus bubalus*). Catch per unit effort (CPUE) was highest for common carp (*Cyprinus carpio*) followed by bigmouth buffalo (*Ictiobus cyprinellus*) in all three units, and by weight in the upper and lower units by number. Total CPUE values for both numbers and weight were the highest in the lower unit for the summer sampling period. The middle unit had the highest species diversity (Table 21) followed by the lower unit and upper unit respectively.

Winter

A total of fourteen species were collected during the winter sampling period (Table 23). There were nine species collected from the lower unit and thirteen species from the middle unit. Largemouth bass was the only species unique to the lower unit. Spotted gar, shortnose gar, yellow bullhead (*Ameiurus natalis*), bowfin (*Amia calva*), and white bass (*Morone chrysops*) were unique to the middle unit. Catch rates of common carp were highest, comprising 68% and 43% of the catch by number, and 71% and 50% of the catch by weight in the lower and middle units, respectively. Bigmouth buffalo had the second highest catch rate, comprising 17% and 27% of the catch by number and 17% and 25% of the catch by weight in the lower and middle units, respectively. Black buffalo (*Ictiobus niger*) had the third highest catch rate, comprising 11% and 12% of the catch by number and 10% and 12% of the catch by weight in the lower and middle units, respectively.

Total CPUE values for both numbers and weight were highest in the middle unit for the winter sampling period. Species diversity (Table 21) was substantially higher in the middle unit.

FYKE NETS

Summer

A total of 23 species were collected during the summer sampling period (Table 24). Of these, the yellow bullhead, threadfin shad (*Dorosoma petenense*), and bighead carp (*Hypopthalymichthys nobilis*) were unique to the lower unit. Smallmouth buffalo and green sunfish (*Lepomis cyanellus*) were unique to the middle unit. Goldfish (*Carrasius auratus*) and orangespotted sunfish (*Lepomis humilis*) were unique to the upper unit. The lower unit was dominated numerically by gizzard shad (*Dorosoma cepedianum*), freshwater drum (*Aplodinotus grunniens*), and shortnose gar, comprising 42%, 19%, and 13% of the total catch, respectively. The lower unit was dominated in terms of weight by shortnose gar, gizzard shad, and freshwater drum, comprising 34%, 25%, and 20% of the total catch, respectively. The middle unit was dominated numerically by black crappie (*Pomoxis nigromaculatus*), gizzard shad, and freshwater drum, comprising 24%, 24%, and 19% of the total catch respectively. The middle unit was dominated in terms of weight by gizzard shad, freshwater drum, and black crappie, comprising 22%, 19%, and 17% of the total catch respectively. The upper unit was dominated numerically by black crappie, bluegill (*Lepomis macrochirus*), and carp, comprising 56%, 27% and

4% of the total catch, respectively. In terms of weight, the upper unit was dominated by black crappie, bowfin, and bluegill, comprising 44%, 38%, and 6% of the total catch, respectively. Total CPUE values for both numbers and weight were highest for the upper unit during the summer sampling period. Species diversity (Table 21) was highest in the lower unit, followed by the middle unit and the upper unit.

Winter

A total of 22 species were collected during the winter sampling period (Table 25). Of these the mooneye (*Hiodon tergisus*), river carpsucker (*Carpiodes carpio*), and orangespotted sunfish were unique to the lower unit. Species unique to the middle unit were spotted gar, black bullhead (*Ameiurus melas*), Channel catfish (*Ictalurus punctatus*), bowfin, carp, green sunfish, and largemouth bass. The lower unit was dominated numerically by gizzard shad, freshwater drum, white crappie. and bluegill, comprising 33%, 14%, 11%, and 11% of the total catch respectively. In terms of weight the lower unit was dominated by gizzard shad, shortnose gar, and white crappie, comprising 29%, 24%, and 18% of the total catch, respectively. The middle unit was dominated in numerically by black crappie, white crappie, and bluegill, comprising 27%, 24%, and 19% of the total catch, respectively. In terms of weight the middle unit was also dominated by black crappie, white crappie, and bluegill, comprising 28%, 25%, and 16% of the total catch, respectively. The total CPUE values for both numbers and weight were much higher in the middle unit than the lower unit during the winter sampling period. Species diversity (Table 21) was also slightly higher in middle unit.

MINNOW FYKE NETS

<u>Summer</u>

A total of 37 species were collected with minnow fyke nets (Table 26). Of these tadpole madtom (*Noturus gyrinus*), ghost shiner (*Notropis buchanani*), black buffalo, and smallmouth buffalo were unique to the lower unit. Species unique to the middle unit were bullhead minnow (*Pimephales vigilax*) and fathead minnow (*Pimephales promelas*). Species unique to the upper unit were brown bullhead (*Ameiurus nebulosus*), bowfin, golden shiner (*Notemigonus crysoleucas*), red shiner (*Cyprinella lutrensis*), river shiner (*Notropis blennius*), and largemouth bass. The lower unit was dominated numerically by gizzard shad, freshwater drum, and emerald shiner (*Notropis atherinoides*), comprising 52%, 16%, and 11% of the total catch, respectively. Due to the capture of several adult fish the lower unit was dominated, in terms of weight by carp, shortnose gar, and freshwater drum, comprising 26%, 26%, and 23% of the total catch, respectively. The middle unit was dominated numerically by gizzard shad, bluegill, and freshwater drum, comprising 73%, 14%, and 6% of the total catch, respectively. In terms of weight the middle unit was dominated by freshwater drum, gizzard shad, and (due to the capture of several adult fish) shortnose gar, comprising 38%, 27%, and 15%

of the total catch, respectively. The upper unit was dominated numerically by western mosquitofish, bluegill, and black crappie, comprising 52%, 16%, and 13% of the total catch, respectively. In terms of weight the upper unit was dominated by black crappie, shortnose gar, and gizzard shad, comprising 50%, 12%, and 10% of the total catch, respectively. The middle unit had by far the greatest CPUE in terms of numbers due mainly to large catches of young of the year (YOY) gizzard shad and bluegill. The lower unit had the highest CPUE in terms of weight due mainly to catches of adult carp and shortnose gar. Species diversity (Table 21) was highest in the lower unit followed by the upper unit and the middle unit.

Seine

A total of 22 species were collected with the seine (Table 27). Of these shortnose gar, skipjack herring (*Alosa chrysochloris*), river shiner, silver chub (*Macryhybopsis storeriana*), bigmouth buffalo, warmouth, and mud darter (*Etheostoma asprigene*) were unique to the lower unit. Unique to the middle unit were largemouth bass and freshwater drum. There wasn't much sampling effort expended seining and these unique occurrences are probably an artifact of sampling variance rather than a true reflection of fish distribution. The lower unit was dominated numerically by gizzard shad, western mosquitofish, and emerald shiner, comprising 35%, 22%, and 15% of the total catch, respectively. In terms of weight the lower unit was dominated by gizzard shad, YOY buffalo, and emerald shiner, comprising 58%, 23%, and 5% of the total catch, respectively. The middle unit was dominated numerically by bluegill, gizzard shad, and western mosquitofish, comprising 54%, 16%, and 15% of the total catch, respectively. In terms of weight the middle unit was dominated by gizzard shad, largemouth bass, and YOY buffalo, comprising 70%, 15%, and 7% of the total catch, respectively. The middle unit had higher CPUE values for both numbers and weight than the lower unit.

Discussion:

Habitat

There were differences in habitat characteristics between the three units that undoubtedly effected fish community composition. The upper unit has a much firmer substrate than either the lower or middle units. This is a result of periodic drawdowns by the area waterfowl manager to enhance moist soil plant production and to facilitate aerial seeding of food plants for migratory waterfowl. These firm substrates and better light penetration have allowed several species of submersed aquatic plants to thrive, providing habitat for fishes as well as food for migratory waterfowl. One drawback to this type of management, from a fisheries perspective, is the reduction of fish passage between the river and backwater.

The middle unit has slightly greater depths than the lower unit with an abundance of dead-fallen timber which provides good habitat for structure oriented fishes. The middle unit is also narrower and consequently more sheltered from wind than the lower unit.

The lower unit is a large, open, relatively structureless area that is prone to high wind generated turbidities. The lower unit also has a large bed of sago pondweed (*Potamogeton pectinatus*) located at the mouth of the lake.

Fish Distribution

Upper Unit

The effects of waterfowl management on the fish community in the upper unit are manifested in several ways. A reduced number of species collected from the upper unit (Table 20), including the absence of common lotic species such as channel catfish, river carpsucker, and smallmouth buffalo indicate that fish passage between the river and backwater has been disrupted. Lower species diversity of both fyke net and trammel net catches in the upper unit (Table 21) also indicate that fish passage between the river and backwater is an important factor controlling fish community composition in this area. The relatively high catch rates of species such as black crappie and bluegill (Table 24) indicate the ability of centrarchid species to thrive in areas with firm substrates, relatively clear water, and lush aquatic plant growth.

Middle Unit

Physical habitat characteristics in the middle unit provided good over-wintering habitat for several fish species. Adult bluegill, black crappie and white crappie showed a preference for the deeper water and woody structure found in the middle unit (Figs. 30 - 31). Adult bigmouth buffalo (Fig. 33) also showed this preference, while carp (Fig. 34) and black buffalo (Fig. 35) showed no real propensity toward either the lower or middle unit.

Lower Unit

The shallow, turbid, structureless lower unit was heavily utilized by carp and bigmouth buffalo during the summer period. The large bed of sago pondweed at the mouth of the lake provided a suitable spawning area, at the appropriate time of the year for these species. The high CPUE during the summer in the lower unit can be attributed to large catches of carp and bigmouth buffalo in and around this bed of sago pondweed. The lack of suitable overwintering habitat for centrarchids is evidenced by the low CPUE values for black and white crappie as well as bluegill.

Fish Population Structure

Objectives

We wanted to determine population structure of the most numerous species within each proposed management unit, and examine seasonal differences in population structure between seasons, prior to project implementation. Determination of population structure using length and age frequency distributions were established, and will be used to determine the impact of the project on reproductive success and recruitment.

Methods:

Length Frequency

All fish collected for community analysis were identified to species and measured to the nearest millimeter to generate length frequency distributions. A subsample of most species were weighed to the nearest gram to establish length-weight regressions for biomass estimates. Specimens that were too small or difficult to identify in the field were preserved in 10% formalin and returned to the lab for identification.

Age determination

A subsample of black crappie (*Pomoxis nigromaculatus*) and freshwater drum (*Applodinotus grunniens*) were sacrificed for age determination. Otoliths were sectioned, mounted onto microscope slides and examined under a dissecting microscope at 7X magnification. A total of four readers examined each otolith. A reading was accepted when three of four readers were in agreement. After two readings any otolith that could not be agreed on was not used.

A data set containing fish from Swan Lake that were aged during the fall of 1984, the fall of 1987, and the spring of 1994 was provided by Chuck Surprenant of the U.S. Fish and Wildlife

Service. The species for which age determinations were made were black crappie, bluegill, freshwater drum, largemouth bass, white bass, and white crappie. All age determinations were made by examining sectioned otoliths.

Results and Discussion:

Length Frequency

Three sunfish species were sampled in sufficient numbers to provide meaningful length frequency distributions. Bluegill, black crappie, and white crappie are shown in figures 30, 31, and 32 respectively. All three species showed a similar population structure. The majority of bluegills captured during both seasons were from 160-210 mm. Figure 30 also shows a large number of these adult fish moving into the middle unit over the winter period. The majority of both black and white crappie, (Figs. 31 and 32, respectively), were between 180-300 mm. These figures also show a large movement of adult fish into the middle unit during the winter period. The majority of the carp sampled (Fig. 34) were between 450-700 mm. Adult carp, unlike the sunfishes were more abundant in the lower unit over both seasons. The majority of the bigmouth buffalo sampled were between 420-540 mm (Fig. 33). These adult fish preferred the lower unit over the summer period, then moved into the middle unit over the winter period. Black buffalo were similar in size to the bigmouth buffalo, ranging from 420-540 mm (Fig. 35). These fish showed no preference for either unit, but did show a migration into both units over the winter period. Freshwater drum (Figure 36) showed a shift in catch composition between seasons. During the summer period the majority of the drum were between 220-370 mm and were evenly distributed between units. During the winter period the majority of the drum were between 90-170 mm and were more abundant in the middle unit.

Black Crappie

A total of 32 otoliths were used for age determination. None of the fish aged during 1992 were younger than three years old. This is a function of the gear used to collect crappie (smaller fish were not susceptible to the fyke nets). The average length of fish determined to be three years of age was 200 mm (Table 28). Four year old fish were an average of 254 mm and five year olds were an average of 282 mm. These lengths at age are slightly greater than those reported by Surprenant in 1984 (Table 30) and 1987 (Table 31) and slightly less than those reported by Surprenant in 1994 (Table 30).

Freshwater Drum

A total of 56 otoliths were used for freshwater drum age determination. Ages ranged from two to nineteen years (Table 28). Mean lengths at age differed substantially from those reported by Surprenant (Tables 29 and 30). Differences in the time of year the samples were collected led to difficulty in comparisons of mean length and weight at age between years. The largest sample was obtained during the spring of 1994 therefore all otolith collections made during the post-project monitoring will be made during the spring.

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Figure 29. Fish sampling sites in Swan Lake.

Table 20. Species collected in Swan Lake from 1 June 1992 - 24 March, 1993 all sampling effort is combined. Species are listed phylogenetically by family, alphabetically by common name.

		Lower unit	Middle unit	Upper unit
Lepisosteidae				
Shortnose gar	*Lepisosteus platostomus*	X	X	X
Spotted gar	*Lepisosteus occulatus*	X	X	X
Ictaluridae				
Black Bullhead	*Ameiurus melas*	X	X	X
Brown Bullhead	*Ameiurus nebulosus*			X
Channel catfish	*Ictalurus punctatus*	X	X	
Tadpole madtom	*Noturus gyrinus*	X		
Yellow bullhead	*Ameiurus natalis*	X	X	
Amiidae				
Bowfin	*Amiia calva*	X	X	X
Clupeidae				
Gizzard shad	*Dorosoma cepedianum*	X	X	X
Skipjack herring	*Alosa chrysochloris*	X	X	
Threadfin shad	*Dorosoma petenense*	X	X	X
Hiodontidae				
Mooneye	*Hiodon tergisus*	X		
Cyprinidae				
Bighead carp	*Hypopthalmichthyes nobilis*	X		
Carp	*Cyprinus carpio*	X	X	X
Bullhead minnow	*Pimephales vigilax*		X	
Emerald shiner	*Notropis atherinoides*	X	X	
Fathead minnow	*Pimephales promelas*	X	X	
Goldfish	*Carassius auratus*	X	X	X
Golden shiner	*Notemigonus crysoleucas*			X
Ghost shiner	*Notropis buchanani*	X		
Red shiner	*Cyrpinella lutrensis*			X
River shiner	*Notropis blennius*	X		X
Silver chub	*Macryhybosis storeriana*	X	X	
Catostomidae				
Black buffalo	*Ictiobus niger*	X	X	X
Bigmouth buffalo	*Ictiobus cyprinellus*	X	X	X
River carpsucker	*Carpiodes carpio*	X	X	
Smallmouth buffalo	*Ictiobus bubalus*	X	X	
Poeciliidae				
Western mosquitofish	*Gamusia affinis*	X	X	X
Atherinidae				
Brook silverside	*Labidesthes sicculus*	X	X	X
Percicthyidae				
White bass	*Morone chrysops*	X	X	X
Yellow bass	*Morone mississippiensis*	X	X	
Centrarchidae				
Black crappie	*Pomoxis nigromaculatus*	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X
Green sunfish	*Lepomis cyanellus*	X	X	
Largemouth bass	*Micropterus salmoides*	X	X	X
Orangespotted sunfish	*Lepomis humilis*	X	X	X
Warmouth	*Lepomis gulosus*	X		
White crappie	*Pomoxis annularis*	X		X
Percidae				
Mud darter	*Etheostoma asprigene*	X		X
Sciaenidae				
Freshwater drum	*Aplodinotus grunniens*	X	X	X
Totals		**36**	**29**	**24**

Table 21. Shannon\Weaver diversity values calculated from mean catches, Summer = 1 June 1992 - 14 September 1992, Winter = 16 November 1992 - 24 March 1993.

		Lower unit	Middle unit	Upper unit
Summer	Trammel net	8.85	14.91	7.83
	Fyke net	34.13	28.13	18.16
	Minnow fyke net	43.40	23.98	37.25
Winter	Trammel net	10.27	22.83	*
	Fyke net	30.56	36.43	*
Total		127.21	126.28	63.24

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Table 22. Catch per unit effort for trammel nets, 1 June 1992 - 14 September 1992, Fishes listed phylogenetically by family, alphabetically by common name.

	Lower unit		Middle unit		Upper unit	
	number	Kg	number	Kg	number	Kg
Lepisosteidae						
Shortnose gar	1.8	1.2	0.2	0.1	0	0
Spotted gar	0	0	0	0	0.2	0.9
Ictaluridae						
Black bullhead	0	0	0.1	*	0.1	0.1
Channel catfish	1.2	2.5	0.4	0.9	0	0
Amiidae						
Bowfin	0	0	1.1	3.2	0.9	2.7
Clupeidae						
Gizzard shad	0.4	0.1	0.3	0.1	0.1	*
Cyprinidae						
Carp	27.3	64.6	15.3	37.3	24.1	60.0
Catostomidae						
Black buffalo	1.3	1.9	2.3	3.8	0.1	0.2
Bigmouth buffalo	6.0	11.1	2.7	5.4	1.6	2.7
Smallmouth buffalo	0.1	0.2	0.2	0.2	0	0
Centrarchidae						
Bluegill	0	0	0.1	*	0	0
Largemouth bass	0	0	0	0	0.6	0.8
Sciaenidae						
Freshwater drum	1.7	0.7	2.8	1.2	1.7	1.7
Totals	**39.8**	**82.3**	**25.5**	**52.2**	**29.4**	**69.1**

* = less than 0.1 Kg

Table 23. Catch per unit effort for trammel nets, 16 November 1992 - 24 March 1993, Fishes listed phylogenetically by family, alphabetically by common name.

	Lower unit number	**Lower unit** Kg	**Middle unit** number	**Middle unit** Kg
Lepisosteidae				
Shortnose gar	0	0	1.5	1.1
Spotted gar	0	0	0.1	0.3
Ictaluridae				
Channel catfish	0.2	0.3	2.4	4.1
Yellow bullhead	0	0	0.1	*
Amiidae				
Bowfin	0	0	0.7	2.2
Clupeidae				
Gizzard shad	0.3	0.1	0.8	0.5
Cyprinidae				
Carp	26.5	54.4	18.7	39.3
Catostomidae				
Black buffalo	4.1	7.8	5.4	9.7
Bigmouth buffalo	6.5	12.7	11.9	19.7
River carpsucker	0.5	0.5	0.5	0.5
Smallmouth buffalo	0.2	0.3	0.1	0.1
Percicthyidae				
White bass	0	0	0.1	0.1
Centrarchidae				
Largemouth bass	0.1	0.1	0	0
Sciaenidae				
Freshwater drum	0.5	0.4	1.7	1.7
Totals	**38.9**	**76.6**	**44.0**	**79.3**

* = less than 0.1 Kg

Table 24. Catch per unit effort for fyke nets, 1 June 1992 - 14 September 1992, Fishes listed Phylogenetically by family, alphabetically by common name.

	Lower unit		Middle unit		Upper unit	
	number	Kg	number	Kg	number	Kg
Lepisosteidae						
Shortnose gar	5.4	3.4	3.1	1.7	2.3	1.1
Spotted gar	0.2	*	0	0	3.0	1.3
Ictaluridae						
Channel catfish	0.1	*	0.1	*	0	0
Yellow bullhead	0.1	*	0	0	0	0
Amiidae						
Bowfin	0.2	0.3	0.2	0.3	6.2	12.6
Clupeidae						
Gizzard shad	16.9	2.5	11.1	2.5	2.8	0.8
Threadfin shad	0.2	*	0	0	0	0
Cyprinidae						
Bighead carp	0.1	*	0	0	0	0
Carp	0.3	0.4	1.5	1.3	7.3	0.1
Goldfish	0	0	0	0	0.2	*
Catostomidae						
Black buffalo	0.1	0.1	0.2	0.1	0	0
Bigmouth buffalo	0.2	0.2	0	0	0.2	*
River carpsucker	0.2	*	0.3	*	0	0
Smallmouth buffalo	0	0	0.1	*	0	0
Percicthyidae						
White bass	1.9	0.3	0.5	*	0	0
Yellow bass	0.2	*	0.1	*	0	0
Centrarchidae						
Black crappie	1.8	0.2	11.2	1.9	95.3	14.8
Bluegill	2.6	0.3	7.8	1.0	46.2	2.0
Green sunfish	0	0	0.1	*	0	0
Largemouth bass	0.1	*	0	0	3.0	0.2
Orangespotted sunfish	0	0	0	0	0.3	*
White crappie	1.7	0.3	1.8	0.3	1.5	0.3
Sciaenidae						
Freshwater drum	7.8	2.0	9.0	2.2	0.5	0.3
Totals	**40.1**	**10.0**	**47.1**	**11.3**	**168.8**	**33.5**

* = less than 0.1 Kg

Table 25. Catch per unit effort for fyke nets, 16 November 1992 - 24 March 1993, Fishes listed Phylogenetically by family, alphabetically by common name.

	Lower unit		**Middle unit**	
	number	Kg	number	Kg
Lepisosteidae				
Shortnose gar	1.3	0.8	5.5	3.0
Spotted gar	0	0	0.1	*
Ictaluridae				
Black bullhead	0	0	0.5	0.2
Channel catfish	0	0	0.1	*
Yellow bullhead	0.4	*	1.3	0.4
Amiidae				
Bowfin	0	0	0.3	0.6
Clupeidae				
Gizzard shad	7.8	1.0	8.0	1.0
Hiodontidae				
Mooneye	0.2	*	0	0
Cyprinidae				
Carp	0	0	0.6	0.3
Goldfish	0.1	*	0.3	*
Catostomidae				
Bigmouth buffalo	0.1	0.1	0.3	0.2
River carpsucker	0.1	*	0	0
Smallmouth buffalo	0.2	*	0.2	*
Percicthyidae				
White bass	2.5	*	2.2	0.1
Yellow bass	0.2	*	0.8	0.1
Centrarchidae				
Black crappie	2.1	0.4	27.4	5.5
Bluegill	2.6	0.4	19.3	3.2
Green sunfish	0	0	0.2	*
Largemouth bass	0	0	0.2	*
Orangespotted sunfish	0.1	*	0	0
White crappie	2.6	0.6	24.4	5.0
Sciaenidae				
Freshwater drum	3.2	0.1	10.2	0.3
Totals	**23.5**	**3.4**	**101.9**	**19.9**

* = less than 0.1 Kg

Table 26. Catch per unit effort for minnow fyke nets, 1 June 1992 - 14 September 1992, Fishes listed Phylogenetically by family, Alphabetically by common name.

	Lower unit		**Middle unit**		**Upper unit**	
	number	grams	number	grams	number	grams
Lepisosteidae						
Shortnose gar	1.2	844.0	0.7	346.7	1.6	299.0
Spotted gar	0.1	21.2	0	0	0.3	142.0
Ictaluridae						
Black bullhead	0.1	0.3	1.4	5.4	0.6	0.4
Brown bullhead	0	0	0	0	0.1	78.9
Channel catfish	0.7	1.1	0.6	0.1	0	0
Tadpole madtom	0.1	*	0	0	0	0
Yellow bullhead	0.7	0.4	0.1	*	0	0
Amiidae						
Bowfin	0	0	0	0	0.4	131.3
Clupeidae						
Gizzard shad	157.5	453.2	906.7	646.5	7.3	257.8
Skipjack herring	1.1	0.3	0.9	2.8	0	0
Threadfin shad	0	0	1.1	1.5	1.2	3.2
Cyprinidae						
Bullhead minnow	0	0	0.1	*	0	0
Carp	23.4	852.5	9.3	28.6	4.2	57.8
Emerald shiner	32.4	11.0	36.0	10.5	0	0
Fathead minnow	0	0	0.5	0.1	0	0
Goldfish	0.4	5.8	0.1	3.5	0	0
Golden shiner	0	0	0	0	7.9	1.3
Ghost shiner	0.1	*	0	0	0	0
Red shiner	0	0	0	0	0.1	0.3
River shiner	0	0	0	0	0.2	0.1
Silver chub	0.1	0.1	0.2	*	0	0
Catostomidae						
Black buffalo	0.8	1.9	0	0	0	0
Bigmouth buffalo	0.1	*	0.2	0.5	0.1	0.1
River carpsucker	0.1	34.9	0.2	*	0	0
Smallmouth buffalo	0.2	0.1	0	0	0	0
Unidentified buffalo	1.7	2.9	13.1	21.8	0	0
Poeciliidae						
Western mosquitofish	1.6	0.6	0.5	0.1	86.6	14.3
Atherinidae						
Brook silverside	0.1	0.1	0	0	5.0	1.0
Percicthyidae						
White bass	1.6	5.0	2.6	26.8	0.1	0.6
Centrarchidae						
Black crappie	1.4	63.2	14.0	217.2	17.3	1349.6
Bluegill	29.6	15.7	169.0	89.0	26.3	41.1
Green sunfish	0.1	*	0.1	*	0	0
Largemouth bass	0	0	0	0	6.7	33.7
Orangespotted sunfish	0.1	0.3	4.1	4.7	1.3	1.5
White crappie	1.2	185.6	2.9	73.6	0.2	60.5
Percidae						
Mud darter	0.1	*	0	0	0.4	0.3
Sciaenidae						
Freshwater drum	47.6	726.5	78.1	899.5	0.1	52.9
Totals (weight in Kg)	**304.2**	**3.2**	**1242.5**	**2.4**	**168.0**	**2.6**

* = less than 0.1 grams

Table 27. Catch per unit effort for seines, 8 July 1992 - 9 July 1992, Fishes listed Phylogenetically by family, alphabetically by common name.

	Lower unit		**Middle unit**	
	number	grams	number	grams
Lepisosteidae				
Shortnose gar	0.7	0.4	0	0
Clupeidae				
Gizzard shad	60.0	79.7	33.7	279.6
Skipjack herring	0.2	0.2	0	0
Cyprinidae				
Carp	8.5	4.9	2.5	3.3
Emerald shiner	25.5	6.5	8.5	2.3
Fathead minnow	0.2	*	0.5	0.1
River shiner	0.3	0.1	0	0
Silver chub	0.2	0.1	0	0
Catostomidae				
Bigmouth buffalo	0.2	0.4	0	0
River carpsucker	6.0	2.3	0.3	4.9
Unidentified buffalo	19.2	31.1	16.8	28.1
Poeciliidae				
Western mosquitofish	36.8	5.9	32.5	8.3
Atherinidae				
Brook silverside	2.8	0.6	0.5	0.2
Percicthyidae				
White bass	0.7	1.5	0.2	0.2
Centrarchidae				
Black crappie	0.2	0.2	0.7	0.6
Bluegill	8.2	0.7	117.0	12.9
Green sunfish	0.2	0.1	0.2	0.1
Largemouth bass	0	0	0.3	60.7
Orangespotted sunfish	0.2	1.5	1.3	0.4
Warmouth	0.2	0.1	0	0
Percidae				
Mud darter	0.2	0.1	0	0
Sciaenidae				
Freshwater drum	0	0	0.2	0.5
Totals	170.5	136.4	215.2	402.2

* = less than 0.1 grams

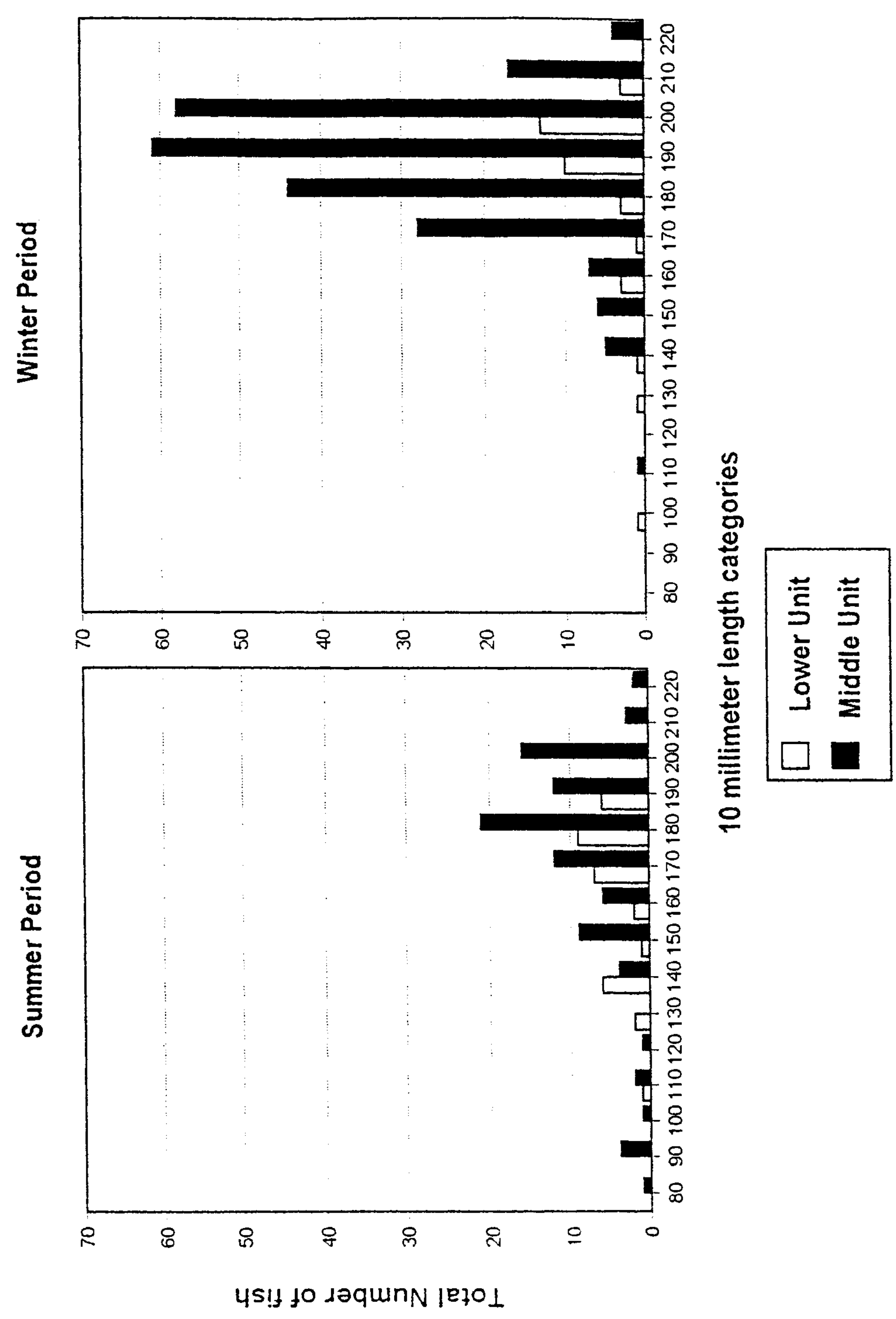

Figure 30. Length frequency distribution for bluegill from summer and winter fyke and trammel net sampling.

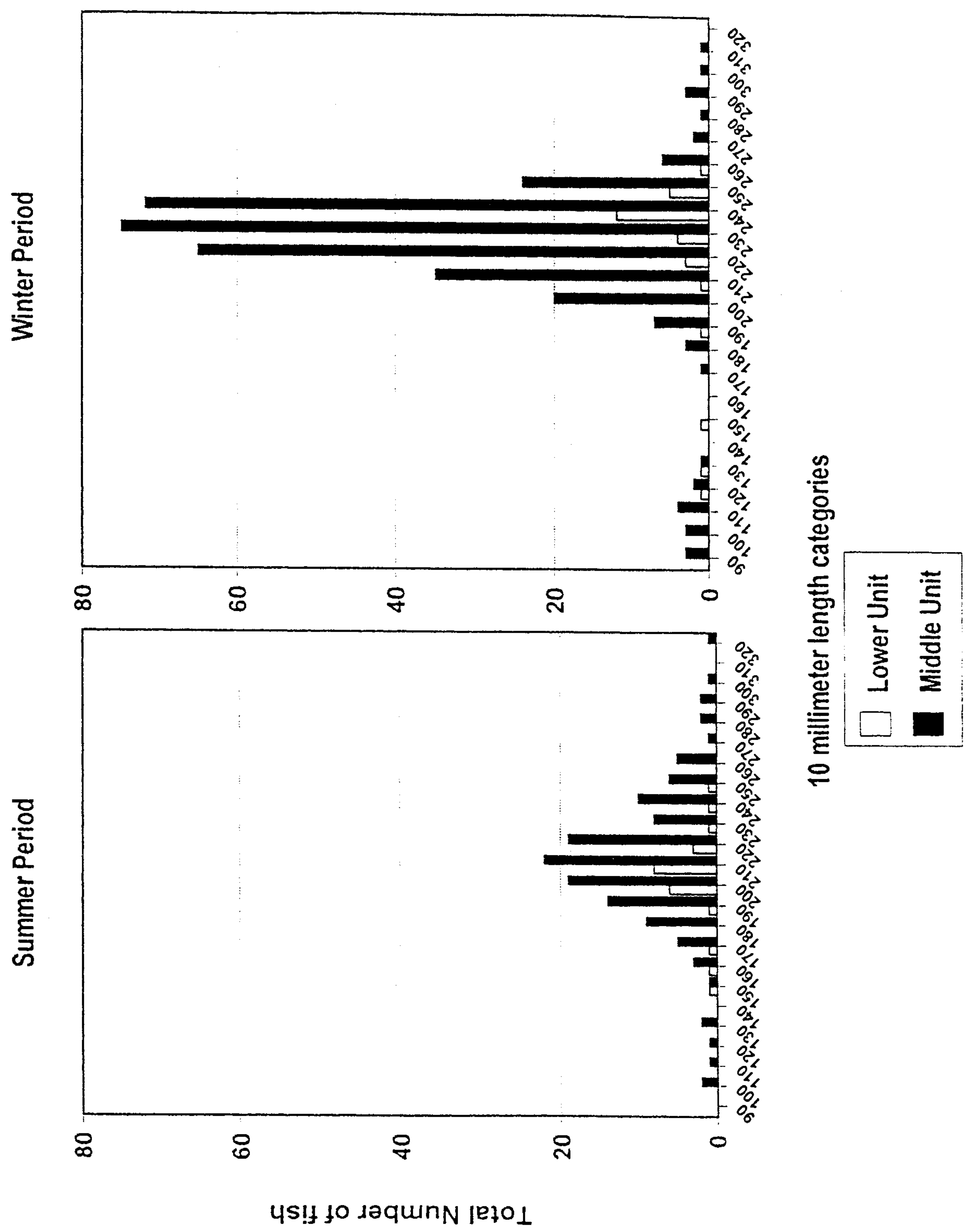

Figure 31. Length frequency distribution for black crappie from summer and winter fyke and trammel net sampling.

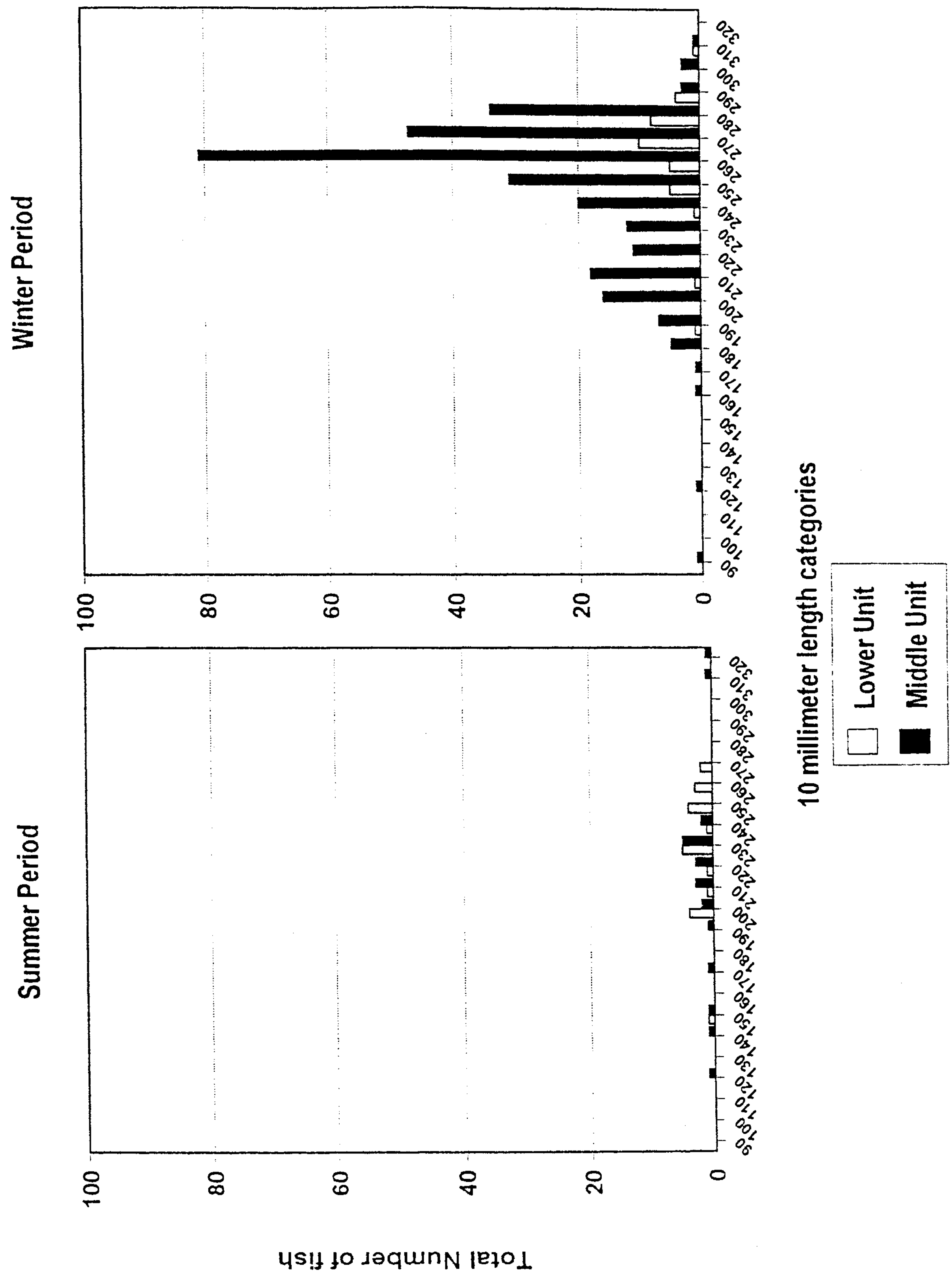

Figure 32. Length frequency distribution for white crappie from summer and winter fyke and trammel net sampling.

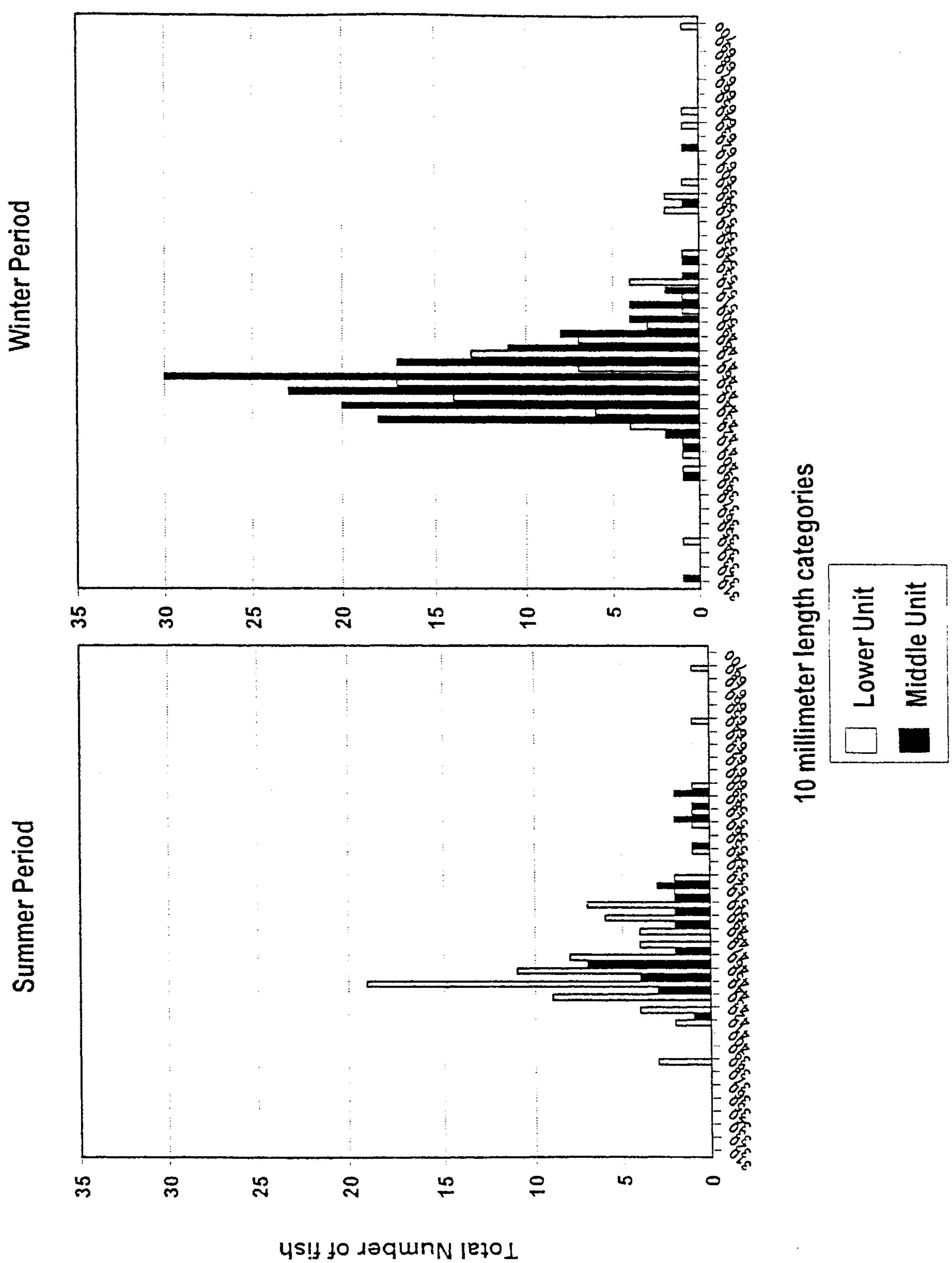

Figure 33. Length frequency distribution for bigmouth buffalo from summer and winter fyke and trammel net sampling.

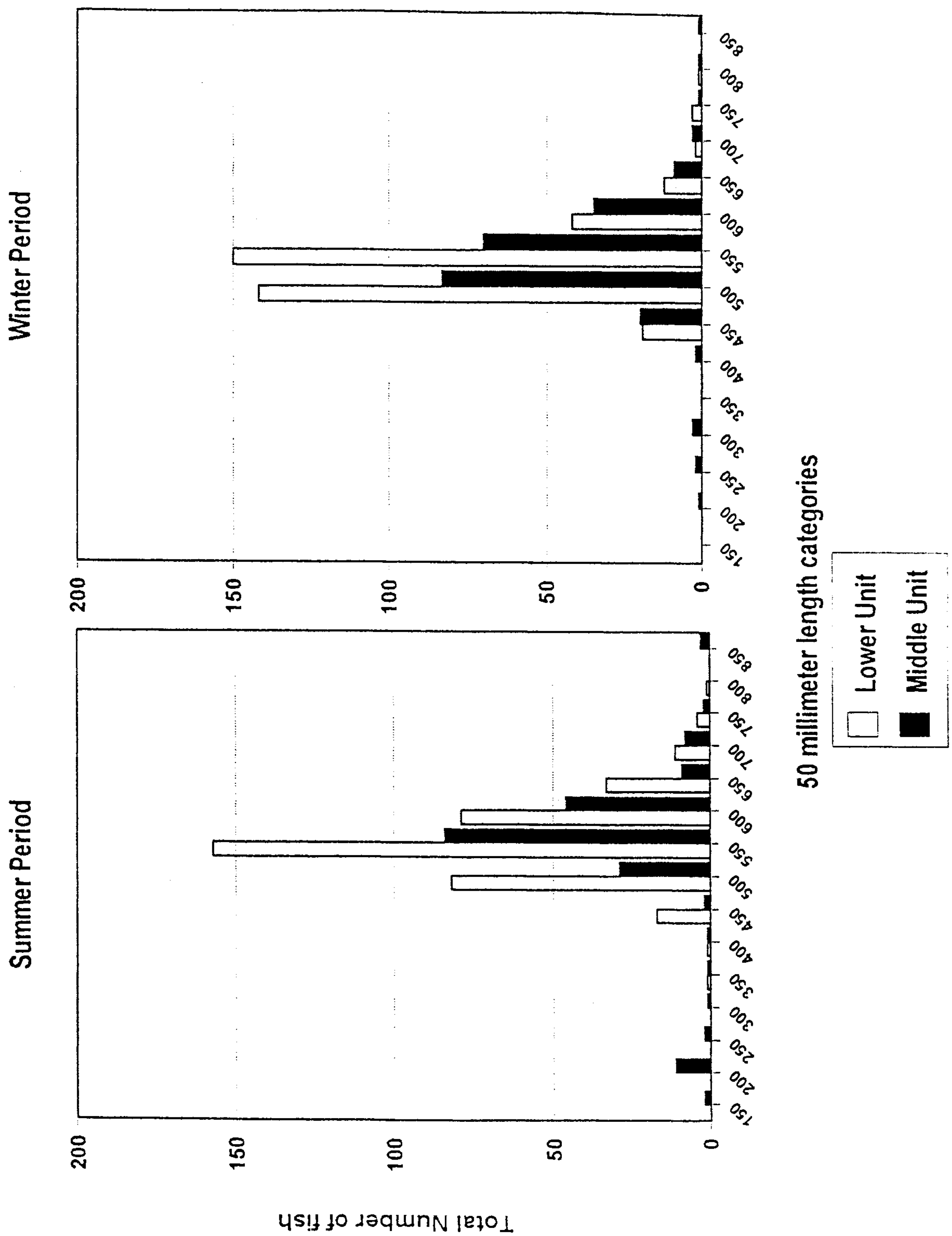

Figure 34. Length frequency distribution for common carp from summer and winter fyke and trammel net sampling.

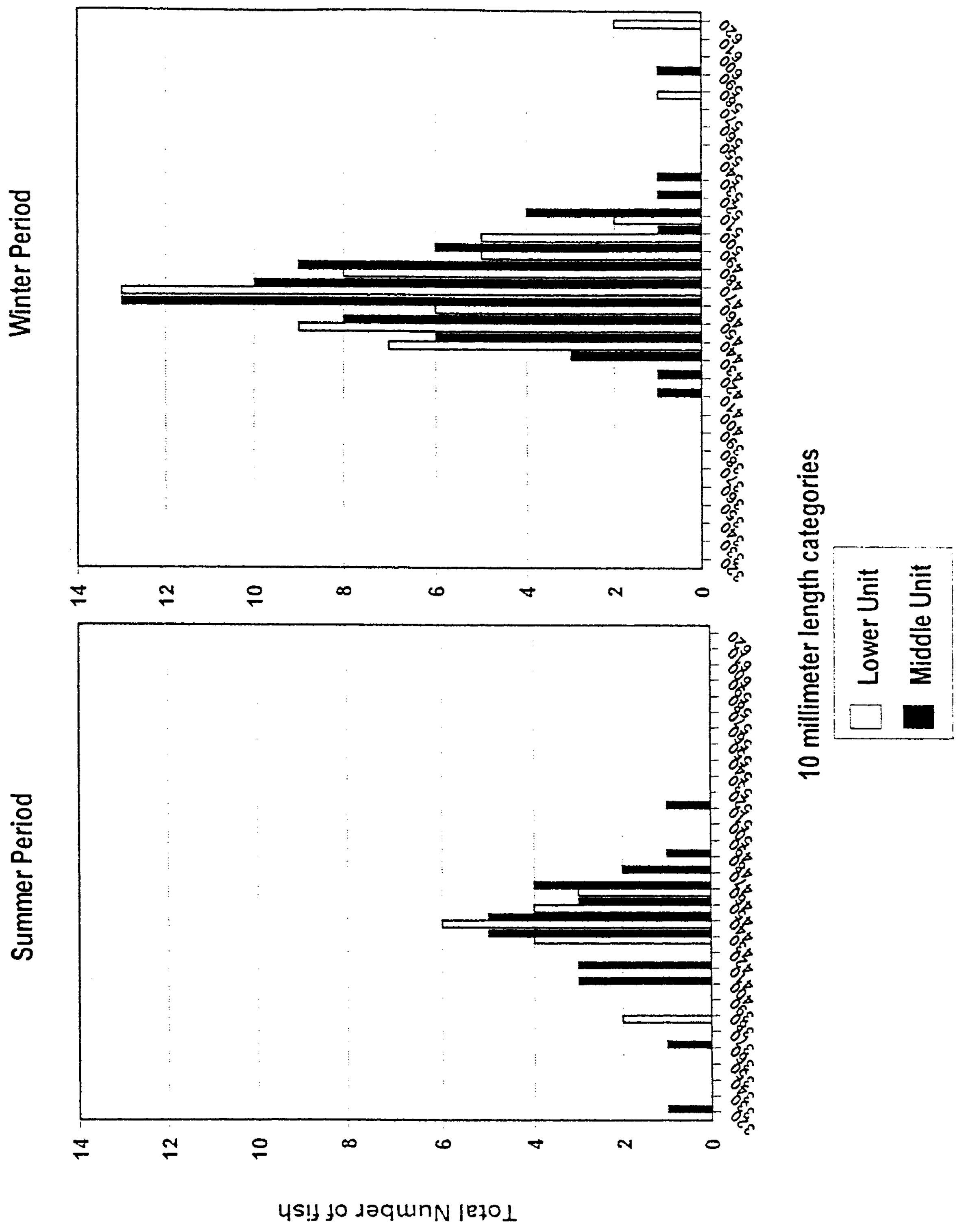

Figure 35. Length frequency distribution for black buffalo from summer and winter fyke and trammel net sampling.

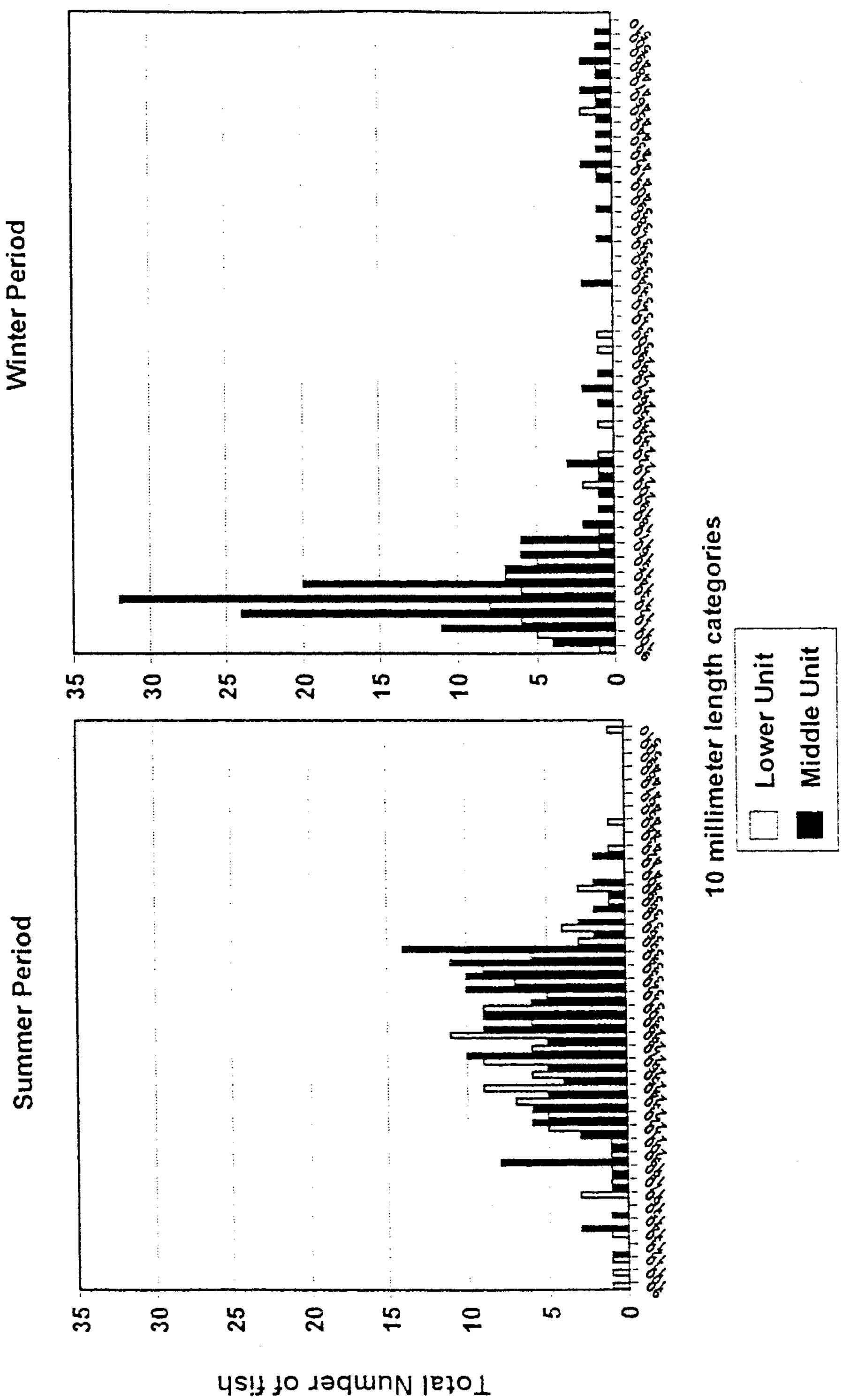

Figure 36. Length frequency distribution for freshwater drum from summer and winter fyke and trammel net sampling.

Table 28. Mean Length (in millimeters) of fishes collected from Swan Lake in summer of 1992. All fish were aged by examining sectioned otoliths, all ageing was done by personnel at the Illinois Natural History Survey, Pool 26 field station.

Species	Age	n	Year Class	Mean Length (STD dev)
Black crappie	3	25	1989	199.8 (84.9)
	4	4	1988	253.5 (11.5)
	5	3	1987	282.0 (4.0)
Freshwater drum	2	4	1990	148.0 (20.1)
	3	3	1989	188.3 (5.7)
	4	7	1988	247.4 (48.4)
	5	5	1987	301.6 (21.0)
	6	7	1986	308.1 (14.9)
	7	4	1985	307.0 (19.3)
	8	7	1984	326.9 (54.3)
	9	4	1983	348.3 (79.9)
	10	4	1982	389.0 (47.6)
	11	3	1981	335.0 (39.8)
	12	2	1980	398.5 (82.7)
	13	2	1979	388.5 (72.8)
	14	2	1978	340.0 (0.0)
	16	1	1976	452.0 (.)
	19	1	1973	337.0 (.)

Table 29. Mean Length (in millimeters) and Mean Weight (in grams) of fishes collected from Swan Lake in fall of 1984. all fish were aged by examining sectioned otoliths, all ageing was done by personnel at the U.S. Fish and Wildlife, Fisheries Assistance Office, Carterville, IL

Species	Age	n	Year Class	Mean Length (STD dev)	Mean Weight (STD dev)
Black crappie	2	1	1983	104.1 (.)	.
	3	23	1982	202.0 (21.8)	112.6 (29.8)
	4	45	1981	224.6 (19.4)	171.8 (56.8)
	5	2	1980	208.3 (25.1)	136.6 (41.2)
	6	2	1979	265.4 (1.8)	289.0 (28.5)
White crappie	2	4	1983	178.4 (8.6)	58.2 (11.6)
	3	9	1982	205.2 (29.7)	114.0 (37.8)
	4	12	1981	248.5 (19.0)	202.3 (54.6)
	7	2	1978	281.9 (7.2)	365.1 (41.2)
Bluegill	2	8	1983	132.4 (15.9)	46.7 (20.2)
	3	6	1982	173.6 (14.7)	115.7 (33.3)
	4	10	1981	185.9 (9.7)	143.8 (32.4)
	5	2	1980	195.6 (0.0)	174.7 (6.3)
Largemouth bass	1	1	1984	170.2 (.)	67.2 (.)
	2	2	1983	193.0 (3.6)	85.1 (44.4)
	4	1	1981	358.1 (.)	757.1 (.)
White bass	1	3	1984	116.8 (17.8)	. (.)
	2	4	1983	196.2 (23.3)	82.8 (22.7)
	3	3	1982	265.9 (61.4)	301.7 (208.5)
Freshwater drum	2	7	1983	120.1 (15.1)	22.4 (0)

Table 30. Mean Length (in millimeters) and Mean Weight (in grams) of fishes collected from Swan Lake in fall of 1987. all fish were aged by examining sectioned otoliths, all ageing was done by personnel at the U.S. Fish and Wildlife, Fisheries Assistance Office, Carterville, IL

Species	Age	n	Year Class	Mean Length (STD dev)	Mean Weight (STD dev)
Black crappie	2	8	1986	154.0 (18.8)	57.7 (29.8)
	3	9	1985	175.8 (15.4)	86.6 (23.4)
	4	7	1984	234.4 (21.2)	213.8 (71.7)
	5	5	1983	248.4 (18.3)	258.0 (75.1)
	7	2	1981	294.6 (3.6)	427.8 (34.9)
White crappie	1	1	1987	81.3 (.)	. (.)
	2	2	1986	129.5 (18.0)	26.9 (6.3)
	3	1	1985	203.2 (.)	125.4 (.)
	4	3	1984	264.2 (6.7)	313.6 (22.4)
	5	2	1983	266.7 (14.3)	266.6 (60.2)
	7	1	1981	312.4 (.)	488.3 (.)
Bluegill	2	1	1986	137.2 (.)	44.8 (.)
	3	2	1985	176.5 (1.8)	145.6 (15.8)
	4	2	1984	162.6 (18.0)	91.8 (34.8)
	5	2	1983	189.2 (19.8)	161.3 (88.7)
Largemouth bass	3	1	1985	279.4 (.)	367.4 (.)
White bass	1	11	1987	142.4 (17.0)	33.8 (15.0)
	2	1	1986	213.4 (.)	116.5 (.)
Freshwater drum	1	10	1987	128.8 (27.6)	29.4 (9.6)
	2	1	1986	221.0 (.)	138.9 (.)
	3	3	1985	250.6 (18.7)	156.8 (9.0)
	4	7	1984	250.7 (26.7)	191.4 (70.0)
	5	4	1983	276.9 (58.2)	272.2 (141.4)
	6	3	1982	327.7 (19.2)	400.2 (40.4)
	7	4	1981	313.1 (12.0)	377.4 (52.0)
	8	3	1980	315.8 (20.5)	400.2 (40.4)
	9	3	1979	324.3 (25.4)	403.2 (76.6)

Table 31. Mean Length (in millimeters) and Mean Weight (in grams) of fishes collected from Swan Lake in spring of 1994. all fish were aged by examining sectioned otoliths, all ageing was done by personnel at the U.S. Fish and Wildlife, Fisheries Assistance Office, Carterville, IL

Species	Age	n	Year Class	Mean Length (STD)	Mean Weight (STD)
Black crappie	1	43	1993	98.7 (10.5)	13.6 (4.7)
	2	68	1992	188.9 (13.3)	101.2 (22.6)
	3	21	1991	214.3 (25.3)	164.8 (59.6)
	4	84	1990	259.2 (28.0)	314.6 (113.4)
	5	4	1989	285.8 (14.7)	398.0 (86.7)
	6	3	1988	267.0 (87.0)	422.7 (318.7)
	7	1	1987	314.0 (.)	502.0 (.)
White crappie	1	7	1993	82.3 (16.3)	6.3 (4.5)
	2	3	1992	183.7 (29.0)	78.7 (46.2)
	3	12	1991	245.3 (21.0)	229.7 (71.2)
	4	23	1990	287.7 (26.9)	419.0 (138.9)
	5	2	1989	293.0 (1.4)	271.0 (222.0)
	7	2	1987	280.0 (84.9)	438.0 (427.1)
Bluegill	1	31	1993	111.3 (31.1)	40.4 (31.9)
	2	9	1992	160.9 (19.3)	98.2 (44.7)
	3	21	1991	181.3 (12.3)	143.1 (32.5)
	4	17	1990	192.2 (13.5)	167.2 (38.5)
	5	1	1989	191.0 (.)	152.0 (.)
Freshwater drum	1	23	1993	150.3 (36.9)	39.1 (34.6)
	2	2	1992	230.5 (34.6)	181.0 (1.4)
	3	4	1991	293.3 (25.2)	267.8 (78.9)
	4	10	1990	304.6 (16.2)	339.1 (79.6)
	5	1	1989	345.0 (.)	550.0 (.)
	6	4	1988	388.5 (62.0)	888.0 (425.4)
	7	6	1987	413.3 (57.8)	1109.8 (542.2)
	8	6	1986	411.7 (335.6)	1084.8 (298.2)
	9	7	1985	430.7 (22.3)	1280.9 (235.9)
	10	6	1984	452.5 (38.9)	1527.3 (487.0)
	11	9	1983	453.9 (27.1)	1464.6 (325.8)
	12	2	1982	494.0 (15.6)	2075.0 (176.8)
	13	2	1981	482.5 (21.9)	1550.0 (282.8)
	14	1	1980	477.0 (.)	1500.0 (.)
	15	4	1979	435.5 (60.8)	1206.3 (603.6)
	16	1	1978	478.0 (.)	1500.0 (.)
	17	1	1977	442.0 (.)	1200.0 (.)
	18	1	1976	445.0 (.)	1200.0 (.)

Summary and Conclusions

The major resource problems considered by this project were substantiated by pre-project monitoring, so were many of the concerns expressed by fisheries biologists involved with project planning. Low water clarity in Swan Lake is apparently related to soft sediments that are easily resuspended by waves. Sediment trap data indicate that total sediment deposition in our traps was almost 50 times greater than the annualized rate of sediment deposition. Emergent annual aquatic plants are abundant in the upper unit where drawdowns occur and along the shoreline subject to water level fluctuations in the lower and middle units. Submergent aquatic plants occur in the upper (managed) unit and near the mouth of the lake. Invertebrate distribution and abundance is related to plant and sediment types, but the flocculent sediments of the lower and middle units supported higher biomass than the upper unit and vegetated habitats. Total density and biomass estimates from different sample periods and habitats are difficult to compare, however, and do not assess production by invertebrate taxa with different life history strategies. Fish abundance in Swan Lake increased during winter, and the lower and middle units of the lake supported more species and total numbers of fish than did the upper (leveed) unit. A higher frequency of riverine species (buffalo, catfish) and overall abundance of fishes in the open portion of the lake supports the fact that Swan Lake is an important overwintering, and perhaps feeding, habitat for fish.

New information obtained by these studies include: spatial comparisons of water quality, sediment hardness and resuspension estimates, vegetation biomass estimates, invertebrate distribution and biomass, and within lake fish community composition and distribution. Water quality studies substantiated perceived differences between the upper and lower parts of the lake, and will provide data necessary to test project induced changes. Sediment study results were not surprising, but will be valuable to test project effects. Vegetation studies will also provide data to test project effects. Invertebrate sampling results were surprising in that the vegetated habitats, typically assumed to harbor a greater biomass of invertebrates, had the lowest biomass. The highest invertebrate biomass was found in the soft substrates, typically assumed to be poor fish and wildlife habitat. Within lake fish community composition and distribution studies supported many assumptions, but also provided much new information. The upper unit provides only ephemeral fish habitat because of water level management practices that include total drawdowns; the middle and lower unit, however, provide year-round habitat. Fish distribution in the lower and middle unit changed between summer and winter seasons. Fish used the middle unit more in the winter than in the summer which may indicate it's present value as a winter fish refuge.

Since most of the physical resource problems (sediment resuspension, sediment transport from the river, and lack of submersed and emergent plants) considered in the Swan Lake HREP design were shown to be true, the project will likely be able to manage them. However, many of the concerns of fisheries managers were also supported by our studies. Since Swan Lake was shown to be an important overwintering habitat, it is imperative that water control structures allow fish movement also. Fish will be impacted if they cannot use all types of control structures to move to preferred habitats throughout the lake. Fish movement studies are planned for the post-project phase of monitoring.

Although not directly addressed in our studies, we believe Swan Lake is an important feeding habitat for river fishes. We know fish make seasonal movements between the river and the lake, but we also suspect more frequent movements to feed. Benthos biomass was lower in areas that had high fish populations (near the mouth of the lake and in the middle unit) versus areas we believe fish did not concentrate (in the stretch of lake between the lower and middle units). Because there were no detectable physical differences between the lower and middle units, we attribute lower benthic biomass to predation by fishes. Changes in sediment characteristics following project completion will alter invertebrate community composition and therefore impact the fishery beyond the reduced access imposed by the levee and pump system.

It is our conclusion that the project is likely to meet many of it's habitat modification and wildlife objectives, but the local fishery will be severely impacted.

Acknowledgements

This was a large study that could not have been completed without the valuable assistance of our field staff, colleagues, and proposal reviewers. Brad Kerans, J.B. Cammerer, Anjela Redmond, John Nelson, Patricia Gannon, and Jamie Hatcher provided help in the field and lab. Eric Ratcliff provided the LTRMP water quality data, John Nelson provided the LTRMP vegetation data, and Anjela Redmond provided the GIS data. Richard E. Sparks, John Barko, Dave Soballe, Steve Gutreuter, Bob Gaugush, Ken Lubinski, and Pam Thiel provided assistance during planning and reviewed the proposal. Funding was provided from the Environmental Management Program for the Upper Mississippi River System through the U.S. Army Corps of Engineers - St. Louis District, the National Biological Service - Environmental Management Technical Center, and the Illinois Department of Conservation.

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Appendix 1

Associated Research

Many investigations have been conducted in Swan Lake since this project was completed. They are in various states of reporting, but are listed here for those seeking more information on the ecology of Swan Lake.

1. Flood Investigations

Staff at the LTRMP - Pool 26 had a great opportunity to collect information during extreme flooding during summer, 1993. Sampling efforts in and around Swan Lake are summarized in four manuscripts published in the 1993 Flood Observation Report (NBS 1994).

Ratcliff, E.N. and C.H. Theiling. Water quality characteristics during and prior to an extreme flood on the Lower Illinois River.

Redmond, A.S. and J.C. Nelson. Observations of submersed aquatic vegetation in three backwater lakes of the Lower Illinois River before and after the 1993 flood.

Theiling, C.H., J.K. Tucker, and P.A. Gannon. Nektonic invertebrate distribution and abundance during prolonged summer flooding on the Lower Illinois River.

Maher, R.J. Observations of fish community structure and

reproductive success in flooded terrestrial areas during and extreme flood on the Lower Illinois River.

2. **Post Flood Investigations**

Most post flood investigations are still in preparation, but are mentioned briefly here to alert readers to future references.

Illinois State water Survey. Dr. Mike Demissie coordinated post flood sampling activities that investigated: sediment deposition, sediment chemistry, sediment contaminants, and sediment toxicity. Preliminary results are available and a report is in preparation.

National Biological Service, LTRMP. Dr. Yao Yin is coordinating post-flood forestry studies to detect flood induced tree mortality. Preliminary results are available and a report is in preparation.

3. **Sediment Studies**

Sediment investigations from the first phase of pre-project HREP monitoring were deemed inadequate and have been supplemented with additional efforts.

Waterway Experiment Station/NBS - EMTC, INHS. Dr. John Barko is coordinating studies that investigate: sediment nutrients, sediment deposition, sediment composition, sediment hardness, and compaction upon exposure. The first phases of the studies are completed, sediment compaction and hardness will be completed in 1995.

James, W.F., H.L. Eakin, and J.W. Barko. in review. Net annual sediment accretion, sediment composition, and rates of sediment nutrient flux in Swan Lake, Illinois.

4. **Mussel Studies**

John Tucker (INHS-Pool 26 Field Station) has contributed significant effort to mussel sampling in and around Swan Lake. He has two papers published and one in press that deal specifically with Swan Lake.

Tucker, J.K., C.H. Theiling, K.D. Blodgett, and P.A. Thiel. 1993. Initial occurrences of zebra mussels (Dreissena Polymorpha) on freshwater mussels (Family Unionidae) in the Upper Mississippi River System. Journal of Freshwater Ecology 8(3):245-251.

Tucker, J.K. and E.R. Atwood. 1995. Contiguous backwater lakes as possible refugia for Unionid mussels in areas of heavy zebra mussel (Dreissena Polymorpha) colonization. Journal of Freshwater Ecology 10(1).

Tucker, J.K., C.H. Theiling, and J.B. Cammerer. Utilization of backwater habitats by unionid mussels on the Lower Illinois River and in Pool 26 of the Upper Mississippi River. Transactions of the Illinois State Academy of Science.

5. **Reptile Studies**.

John Tucker has also devoted effort to sampling reptiles in Swan Lake. His efforts have resulted in two manuscripts related to Swan Lake reptiles.

Tucker, J.K. and J.B. Cammerer. 1994. Nerodia rhombifer rhombifer (diamondback water snake) reproduction. Herpetological Review 25(1):28-29.

Tucker, J.K., R.J. Maher, and C.H. Theiling. in press. Year-to-year variation in growth in the red-eared turtle, Trachemys scripta elegans. Herpetologica.